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CIVIL ENGINEERING.

Supply of Water to Cities.—The Cisterns of Venice.

From the Practical Mechanic's Journal, April, 1863.

EVERY city, and all living things, are supplied with water by rain in one form or other, namely, by that fraction of the total rain that falls, which is not again rapidly evaporated, but collected upon the surface, is drawn into reservoirs of some shape or sort. Most generally these reservoirs are found in the rivers or perennial streams, that pass cities and towns founded on their banks;—sometimes, but rarely, in lakes, upon the shores of which, or upon islands wholly water-surrounded, they have been fixed; as in the cases of the ancient capital of Mexico and of Mantua, &c. More rarely still, and chiefly as a result of modern engineering, the reservoir has been an artificial one, collecting its waters from the rain falling on "gathering grounds," *i. e.*, upon a determinate surface of dry ground. Spring wells, Artesian or otherwise, are no exception, as all water-bearing strata are but subterraneous reservoirs of rain, with the advantage, and sometimes the disadvantage, that here the rain, in its permeation of the earth to the fissures beneath, becomes filtered and purified, or takes up new mineral matter, and may change its temperature inconveniently, as well as its chemical constitution.

Most rarely of all, and as quite an exceptional case, a few communities at great elevations, or in the more rigorous climates of tempe-

rate zones, have been dependent for water, upon the snow and ice melting close around them.

Thus there does not seem anything strange at first sight in a city supplied wholly by rainfall; but there is everything both remarkable and unusual, in a great city dependent for its water supply upon *the surface only which itself covers*, and collected altogether in small and artificial reservoirs. Yet such is the water supply of Venice, the inhabitants of which are in the position of the crew of a large ship, who should depend for their water upon the rain and dew that fell upon the deck, having provided means that the whole of this should run down as it fell into the tanks in the hold.

Venice, once the queen of the Adriatic, still sits, though in mourning and dethroned, upon the site of her ancient glory,—sea-surrounded, in the great salt Lagune,—upon a cluster of islets, many of them artificial,—none better than banks and ancient delta shoals, and until the railway viaduct bridged the westward waters, truly insulated,—for the most part practically so now,—for each islet is cut off from others by the intervening canals.

The city, including numerous small gardens and courts, with its public places, &c., covers an area of 5,200,000 square metres, or nearly 1289 statute acres, exclusive of canals, small and great. In average years there fall 32·3 inches of rain. Almost the whole of what falls over the surface of the city—upon its roofs, gardens, courts, and public places, is collected into no less than 2077 cisterns, of which 177 are public property, the remaining 1900 belonging to private individuals.

The total capacity of all these cisterns united, is seven millions one hundred and sixty thousand six hundred cubic feet.

The rain gauge kept at the Patriarchal Seminary proves that sufficient rain falls, and at intervals, such as to be capable of filling all these cisterns five times per annum. This gives a supply for each of the inhabitants of 5·28 Imperial gallons English per day in gross; but as nearly one-third of the storage capacity of the cisterns is occupied by sand for filtration, we must deduct its bulk, and this reduces the available supply to 3·52 gallons per head per day. This is a very inadequate supply for any climate, but is especially so for a warm one. It is not much more than one-sixth of what British hydraulic engineers have fixed upon as a moderate amount; nor does it reach one-twentieth of the ample volume with which several British and French cities, such as Glasgow and Marseilles, have been artificially supplied.

Venice, however, is exceptional in point of position, and also in dispensing with some demands for water, arising from its position. From the almost total absence of cesspools and sewerage, the canals become the receptacles of all the filth and refuse of the city; there is, therefore, little or no demand for water for flushing, or in any other way in connexion with sewerage. Again, by the habits of the country, most of the washing of clothes is performed upon the open waters of the canals of the Lagune, and but little of the precious fresh water is thus consumed.

The point of greatest interest in the water supply of Venice, however, is found in the admirably simple, and yet perfect construction of the cisterns, or wells as they are called, in which the rain water is collected and preserved. This construction mounts to a remote era; and like the granaries excavated out of the dry cretaceous limestone of Malta,—as is supposed by the knights of Malta, ages ago, and in which grain is even now kept for lengthened periods perfectly good,—these cisterns present a remarkable example of the highest ingenuity, and skilful adaptation by the self-taught engineers of the middle ages, of materials the very simplest and cheapest, combined to attain with perfection the end desired.

Fig. 1.

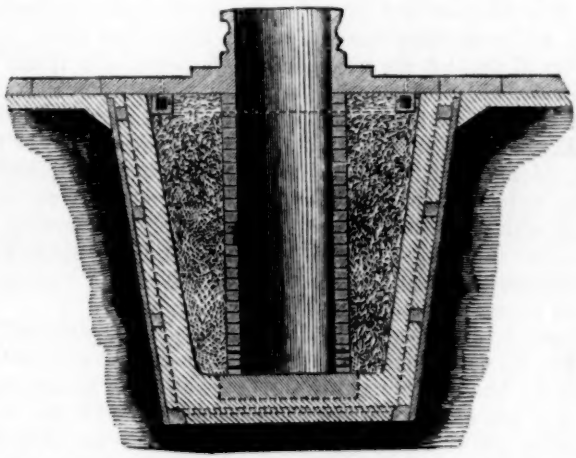


Fig. 1 is a vertical section of one of these cisterns; and figs. 2 and 3 are horizontal sections, showing their construction. They are all

Fig. 2.

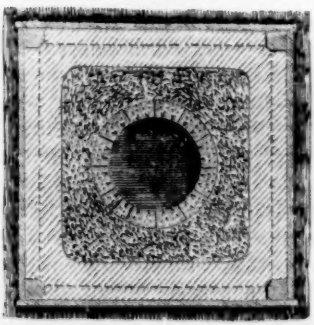
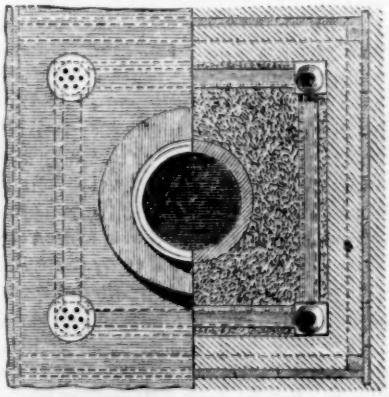


Fig. 3.



made upon one established orthodox plan, and have been so for ages. The objects in view in these cisterns were to produce the means of col-

lecting the rain water from roofs and open surfaces, to filter it at once upon its collection, and to pass the filtered water into a storage reservoir, so circumstanced that it should be there preserved pure and cold.

Well-tempered clay, sand, and a little rough timber and some brick work, are almost the whole materials of these structures.

To construct one of these wells, an excavation is made in the soil to the depth of 10 or 12 feet—seldom deeper, for beyond this the infiltration of brackish water from the Lagunes is almost everywhere encountered. The excavation is made in the form of a quadrilateral pyramid, with its base uppermost, and truncated below, the area of the bottom being from one-half to three-fourths that of the base at the surface. The sides are cut down flat and square, and the bottom leveled nicely, and sometimes rammed with a little hard stuff, gravel, &c.

The sides of this pit are now lined throughout by a frame planked on the outside, which is roughly put together, generally with treenails; but the exterior planking is *closely jointed*, and the timber is always sound oak, chestnut, or larch timber. Upon the bottom of the pit is laid in, a thickness of 6 or 8 inches of thoroughly well tempered and very stiffly worked clay, each shovelful being perfectly united and incorporated with the rest, and the whole beaten well together, and leveled down by rammers on top. Upon this is laid in, a large flat stone, like a grindstone without an eye, roughly dressed to a circular form all round, and wrought pretty smooth on the top bed.

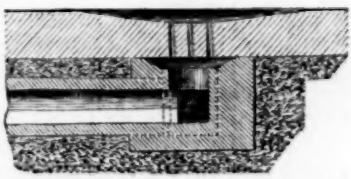
Sometimes these stones are in diameter large, and such as to extend beneath the whole diameter of the cylinder of the well, as shown in figs. 1 and 2; but in other cases, either when large stones have been difficult to procure, or when the diameter of the walls has been made larger than is common (3 to 4 feet being the average diameter), the bottom stone is smaller, and the first courses of bricks are corbelled out over it, course after course all round, until the diameter of the cylinder of the well is gained, so that the bottom of the interior of the well is a sort of inverted cone; this is, however, deemed inferior practice.

Against and upon the inclined surfaces of the timber work, there is now carried up, a thoroughly united bed or wall of well and stiffly tempered clay, well united with the bed of like material beneath the bottom stone, and all round the latter. The utmost care is taken in laying this in, by hand, lump after lump, beating them together, so as not to leave a single crevice or air-hole in the whole mass. Clay of admirable quality, perfectly free from sand or pebbles, is found in abundance, by dredging, in various places about Venice. When this surrounding wall of clay, which is about 12 inches in thickness, has been carried up 3 or 4 feet, the cylinder of the well itself is commenced being built within it, upon the base of the central stone. This is constructed of dry bricks, nicely moulded to the proper form, in curve and radius, and the three or four lowermost courses of bricks are all perforated with holes radially. These holes are not very small, but a few handsful of gravel or pebbles at the back, prevents anything but water passing through them.

The interspace between this cylindrical brick wall and the clay envelope all round, is now filled in, with sifted and washed sand, of a fineness and quality that experience has decided upon as suitable, which is obtained by dredging from the Adriatic, and thus the work is proceeded with until the surface level is nearly reached. Assuming now that the well is intended to receive its water from the surfaces of the roofs, &c., of a Palazzo, or other building, and from that of the interior court in which the well (*Pozzo*) stands, like the *Impluvium* of old Roman houses; the roof water is discharged into surface channels, cut in the flagging of the central court, and the whole of this surface is laid with a very slight fall to the place of the well.

At the four corners of the square of sand, as seen in fig. 3 (of which one-half is a plan above the level of the flagging, &c., and the other a horizontal section a little way below it, at level C, D,) are laid in four perforated blocks of stone, formed as in enlarged section, fig. 4, (parallel to one face of the square,) called *Cassettoni*. These are all connected by a square of tubes of hollow bricks, made like square drain tiles, and perforated with small holes at the sides, looking towards the centre of the well, or sometimes at both sides. All these are simply bedded into the sand firmly, which has been rammed or compressed together gently, as it has been filled in, and wetted occasionally during the process. Above each of the *Cassettoni*, and bedded down in contact with it, is placed a dish, formed and perforated in a square, of flagging, which forms so much of the surface of the court, and receiving all the water coming from roofs or other areas, transmits it down into the horizontal hollow brick perforated tubes, and these into the body of the sand. From the latter the water finds its way, in through the bricks of the cylinder of the well, which it fills gradually up to the top with filtered water. The well is thus a reservoir surrounded by a body of saturated sand, which drains itself dry, as the water by consumption falls in level.

Fig. 4.



Many of these wells are like that shown in the figure "Draw wells," with a low circular or polygonal parapet around them above the surface. This is often of marble, or cast in bronze, and adorned with all the storied beauty of high relieved sculpture, in Byzantine or *cinque cento* style, and unencumbered with any apparatus to draw, but the pitcher and cord; and one often finds beside them such scenes as that so pictorially told in the gospels, of one who at even-tide "sat upon the well," when a Samaritan woman came to draw from it. The water contained in these wells, or cisterns, is always found perfectly fresh, and cool to the palate. Its temperature is, in fact, almost precisely that of the mean temperature of the soil at 10 feet deep, which in Venice is about 52° Fahrenheit, and about the very best for drinking water.

Venice is a city with nearly no soot, and scarcely any dust. Whether wholly from these circumstances, or from others not yet explained, the fact is certain, that these wells continue, without renewal or washing of the sand, to supply water pure and sweet for years, and preserve it cool and fresh to the last drop. In general the demand for water so far exceeds the supply, from the proportion of gathering surface that can be given to these wells, that there is little risk of their overflowing; but the chance of this occurring in one of those semi-tropical rain storms that sometimes pass over this part of Italy, is provided for occasionally by an earthen overflow pipe placed just above the level of the *Cassettoni*, and conducted by an open channel to the nearest outfall. So little are these important, however, that "*una dotta generosa*," a liberal supply, is deemed the highest recommendation by a Venetian, of his well. The grand structural precaution is against the penetration of the wall of puddle or clay, round the sand, by the entrance of the fibrous roots of trees growing in the soil around; these run toward the subterranean water with a sort of instinct that is quite wonderful, and it is against these that the closely-jointed planking is provided mainly. It is said that when this is properly fitted, and the clay laid in without *rigolas* or leakage points, and 12 inches thick, roots are never known to get through; whenever they have been found to do so, their presence is sooner or later found, after they have penetrated into the sand, by their making the water vapid and impure.

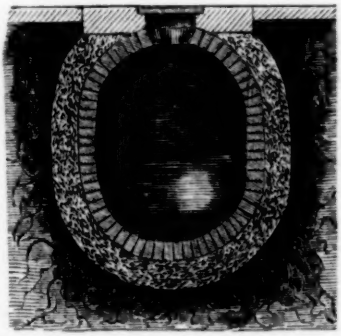
It may be a matter of question, and has not, that we know, as yet been matter of experiment, how far this form of filtration, deprives rain water of some or all of its ammoniacal salts, which are the only impurity, of importance, with which rain comes down loaded. Probably no hydraulic engineer, who had a choice of other good sources of supply, would propose to supply a great city, from rain thus caught and instantly entrapped, before it has had time, by surface or subterranean travel, to get fully ærated, and more or less mineralized, although for everything but drinking, no water can be purer or better than this. There are many places, however, in our own and other countries, where the structural idea of these wells of Venice might be advantageously borrowed for adoption. With ourselves in London, for example, where the hardness of our water makes it objectionable for washing, tea making, &c., there are numbers of the better class of houses in the civic parts proper, and still greater numbers throughout the suburbs, now provided with tanks or water butts, or reservoirs of one sort or other, for rain water delivered from their own roofs, but most generally without any filtration whatever; and as our soot-saturated rain drives the washings of the black roofs all away along with itself into these tanks, so the water is never anything but a brown and ugly, bad flavored liquid. It would seem by no means difficult to modify the construction of these Venetian wells, so that a very cheap and excellent form of filter and storage tank, fitted to our particular conditions, might be devised and adopted by our house builders. The external casing might be made at once of slate slabs, and the sand in-

terposed between it and the sides of the brick-lined well, from which the pumps of two or more houses might draw; and it would be very easy to devise means for removal and washing of the sand, for keeping back all the solid grosser particles in the water before it entered the sand, or even for washing clean the latter by a reverse current occasionally, of common water from the water mains.

The writer of the present paper himself constructed a water tank several years ago, upon methods having considerable analogy with those above described.

It consisted of two hemispheres of 12 feet interior diameter, united by a cylinder of about 4 feet high, and of equal diameter, all of but one brick thickness, laid in common mortar, and built (by taking advantage of the *dome* form) without any centering whatever; the whole being surrounded externally by about 15 inches in thickness of well-tempered and hard beaten clay, laid against the soil cut out to the proper form and size. This tank is still in use, and perfectly water tight. It cost an extremely small sum in proportion to its capacity. It was so placed that no trees could come near it; and the greater portion of the clay was so deep as to be out of the reach of worms. It is shown in fig. 5.

Fig. 5.



The data with which we commenced as to the rainfall and supply of Venice, may be viewed as authenticated, having been derived from Signor Salvadori, the engineer-in-chief to the municipality of Venice. When the railways from Padua and from Treviso were brought into Venice, it was, we believe, intended to have carried in a new water supply also upon the viaduct. We are, however, not aware that this has yet been carried out. The distribution by pipes, in Venice itself, will always be a matter of some engineering difficulty. There is here room for British engineering enterprise, as well as in cleansing the canals from the accumulated putrid silt of ages. So foul is this, and so loaded with phosphorus and sulphur, from the decay of marine animal life and city offal together, that torrents of gas bubbles rise in the wake of every gondola from the bottom, by the slight disturbance of the mud in its passage; and in the twilight gloom of a hot and vapid night in August some years ago, we observed numbers of these gas bubbles, inflame spontaneously, on reaching the surface of the water, in some of the narrower canals of the oldest part of the city, while the water was so loaded with sulphides, that a bright ducat piece lowered down to near the bottom by a string, came up brown after a few minutes immersion. Countless myriads of horrid looking little black crustaceans, fringed the walls at both sides, close to the edge of the water, and rushed up their surfaces, a few inches, as the gondola swept by,

to avoid the ripple that ran along, produced by its passage, and mosquitoes innumerable piped and worried us, in the breathless stench.

It is no wonder that Venice is at all times an unhealthy city, and especially so in the autumn.—Ed.

On the Reconstruction of the Dinting and the Mottram Viaducts.

By Mr. W. Fairbairn, F.R.S., M. Inst. C.E.

From the London Artizan, April, 1863.

After alluding to the many advantages resulting from the application of a tenacious but flexible material, like wrought iron, either in the tubular girder, or other forms in which it was now employed, as being probably the most suitable for bridges and viaducts of great width and span, where strength and durability were required, the author remarked, that at the present time there did not appear to exist any inducement, on the score of economy, for the introduction of a perishable material, such as timber, into structures intended to be of a permanent character. He then briefly described the original condition of the Dinting and the Mottram viaducts, on the Sheffield and Manchester Railway, which were erected in the year 1843-44, under the direction of the late Mr. Joseph Locke. The former consisted of five arches of 125 feet span, and the latter of one arch of 150 feet and two of 125 feet span, constructed of timber ribs on the laminated principle. As was generally the case with similar structures, within ten or twelve years after their erection, the timber was so much decayed as to endanger their security, and to render considerable repairs indispensable. It was then contemplated to substitute iron work, but this step was not finally determined upon until the year 1858, when the viaducts were again in such a state as to alarm the passengers. It was stated that the restored portions for each viaduct consisted of two longitudinal and continuous tubular iron girders, fixed to the middle piers, and free to expand and contract in the direction of the abutments. To the top of these girders iron cross-beams were riveted, on which were laid the longitudinal sleepers for supporting the rails. There was nothing new in the construction of the girders. They were one-thirteenth of the span in depth, and the areas of the top and bottom flanches were in the proportion of 7 to 6, the breaking weight, equally distributed, amounting to 12·58 tons per lineal foot. The chief novelty was in the mode of erection, and in the method of substituting iron for wood; the Directors of the Railway Company having insisted on the condition that the traffic should not be interrupted during the progress of the works. Several plans were proposed, but that which was ultimately adopted was to construct the girders on the old existing platforms, to cut down the piers and the abutments, and then, by a simple mechanical apparatus, first to suspend and afterwards to lower the girders into their places. A strong wooden frame, about 16 feet high, was erected on the pier at each end of the girder, and on the top of this was inserted a cast iron plate, with a hole in the centre, through which a square-threaded screw 4½ inches in dia-

meter was passed. Centred on this screw and resting on the cast iron plate was a bevel wheel, which received motion from a pinion in connexion with spur-gearing worked by crank handles in the ordinary manner. On the lower end of the large screw was forged an eye, to receive a cross-bar, having links at each extremity, which hooked under the angle irons at the sides of the girders. With six men at the handles, each girder was raised and lowered into its place in one hour. When one line of girders was thus completed—the whole of the traffic having in the meanwhile been carried by a single road—a temporary way was laid upon this line of girders, and the traffic was transferred to it. The girders on the other side of the viaduct were next constructed, and when they were finished the iron cross-beams were riveted to these girders, and the permanent way for this line was made good. The trains were again passed on to this road, the permanent way on the other side was laid, the timber arches and the framing were removed, and the viaduct was complete.

Experiments on the Gauging of Water by Triangular Notches.

By James Thomas, M. A., Prof. C. E. Queen's Col. Bel.

From the Lond. Civ. Eng. and Arch. Journal, April, 1863.

With reference to the comparison made, in the concluding sentences of the Report, between the quantities of water which for any given depth of flow are discharged by notches of different widths, and to the opinion there expressed that we might, without danger of falling into important error, pass from the experimental determination of the coefficient for a notch so wide as four times its depth, to the employment of notches wider in any degree, by simply increasing the coefficient in the same ratio as the width of the notch for a given depth is increased, I now wish to add an investigation, since made, which confirms that opinion, and extends the determination of the discharge beyond the notches experimented on, to notches of any widths great in proportion to their depths. This investigation is founded on the formula for the flow of water in rectangular notches obtained from elaborate and careful experiments made on a very large scale by Mr. James B. Francis, in his capacity as engineer to the Water-power Corporation at Lowell, Massachusetts, and described in a work by him, entitled "Lowell Hydraulic Experiments," Boston, 1855. That formula, for either the case in which there are no end-contractions of the vein, or for that in which the length of the weir is great in proportion to the depth of the water over its crest, and the flow over a portion of its length not extending to either end is alone considered, is

$$Q_1 = 3{\cdot}33\, L_1 H_1^{\frac{3}{2}} \quad . \quad . \quad . \quad (1)$$

where L_1 = length of the weir over which the water flows, without end-contractions; or length of any part of the weir not extending to the ends, in feet;

H_1 = height of the surface-level of the impounded water, measured vertically from the crest of the weir, in feet;

and Q_1 = discharge in cubic feet per second over the length L_1 of the weir.

It is to be understood that, in cases to which this formula is applicable, the weir has a vertical face on the upstream side, terminating at top in a level crest; and the water on leaving the crest is discharged through the air, as if the weir were a vertical thin plate.

To apply this to the case of a very wide triangular notch. Let ABC be the crest of the notch, and AC the water level in the impounded pool. Let the slopes of the crest be each m horizontal to 1 vertical;

or, what is the same, let the cotangent of the inclination of each side of the crest to the horizon be $= m$. Let AE, a variable length, $= x$. Then $ED = \frac{x}{m}$. Let EG be an infinitely small element of the horizontal length or width from A to C. Then EG may be denoted by dx. Let q = quantity in cubic feet per second flowing under the length x, that is, under AE in the figure. Then dq will be the quantity discharged per second between ED and GF. Then, by the Lowell formula just cited, we have

$$dq = 3{\cdot}33\, dx\left(\frac{x}{m}\right)^{\frac{3}{2}};$$

whence, by integrating, we get

$$q = 3{\cdot}33\,\frac{1}{m^{\frac{3}{2}}}\cdot\frac{2}{5}x^{\frac{5}{2}} + C,$$

in which the constant quantity is to be put $= 0$, because when $x = 0$, q also $= 0$. Hence we have

$$q = \tfrac{2}{5} \times 3{\cdot}33\,\frac{1}{m^{\frac{3}{2}}}\,x^{\frac{5}{2}} \quad . \quad . \quad . \quad (2)$$

Let now H_2 = height in feet from the vertex of the notch up to the level surface of the impounded water = BK in the figure. Then AK $= m H_2$. Let also Q_2 = the discharge per second in the whole triangular notch = twice the quantity discharged under AK. Then, by formula (2), we get

$$Q_2 = \tfrac{4}{5} \times 3{\cdot}33 \times \frac{1}{m^{\frac{3}{2}}}(m H_2)^{\frac{5}{2}};\ \text{or}$$

$$Q_2 = 2{\cdot}664\, m\, H_2{}^{\frac{5}{2}} \quad . \quad . \quad . \quad (3)$$

To bring the notation to correspond with that used in the foregoing report, let Q = the quantity of water in cubic feet per minute, and H = the height of the water level above the vertex in inches. Then

$$Q_2 = \frac{Q}{60},\ \text{and}\ H_2 = \frac{H}{12};$$

and, by substitution in (3), we get

$$Q = {\cdot}320\, m\, H^{\frac{5}{2}} \quad . \quad . \quad . \quad (4)$$

This formula then gives, deduced from the Lowell formula, the flow

in cubic feet per minute through a *very wide notch* in a vertical thin plate, when H is the height from the vertex of the notch up to the water level in inches, and when the slopes of the notch are each *m* horizontal to 1 vertical.

As to the confidence which may be placed in this formula, I think it clear that, for the case in which the notch is so wide, or what is the same, the slopes of its edges are so slight that the water may flow over each infinitely small element of the length of its crest without being sensibly influenced in quantity by lateral contraction arising from the inclination of the edges, the formula may be relied on as having all the accuracy of the Lowell formula from which it has been derived; and I would suppose that when the notch is of such width as to have slopes of about four or five to one, or when it is of any greater width whatever, the deviation from accuracy in consequence of lateral contraction might safely be neglected as being practically unimportant or inappreciable.

This formula for wide notches bears very satisfactorily a comparison with the formulas obtained experimentally for narrower notches, as described in the foregoing report. For slopes of one to one the formula $Q = \cdot 305\ H^{\frac{5}{2}}$, and for slopes of two to one the formula was $Q = \cdot 636\ H^{\frac{5}{2}}$. To compare these with the one now deduced for any very slight slopes, we may express them thus:—

For slopes of 1 to 1	$Q = \cdot 305\, m\, H^{\frac{5}{2}}$
And for slopes of 2 to 1 . . .	$Q = \cdot 318\, m\, H^{\frac{5}{2}}$
While for any very slight slopes, or for any very wide notches, the formula now deduced from the Lowell one is . .	$Q = \cdot 320\, m\, H^{\frac{5}{2}}$

The very slight increase from ·318 to ·320 here shown in passing from the experimental formula for notches with slopes of two to one, to notches wider in any degree—that slight change, too, being in the right direction, as is indicated by the *increase* from ·305 to ·318 in passing from slopes of one to one to slopes of two to one—gives a verification of the concluding remarks in the foregoing report; and this may serve to induce confidence in the application in practice of the formula now offered for wide notches.

Structures in the Sea, without Coffer Dams: with a Description of Works of the New Albert Harbors at Greenock. By D. MILLER.

From the London Artizan, May, 1863.

It was stated that the immediate object of this paper was to treat of the various methods of constructing the foundations of quays, walls, piers, or breakwaters, for the formation of docks and harbors in deep water; and to describe works of this kind which have been carried out on principles different to those usually practised, and to point out the further application of those principles to other structures of a similar nature. The plans which had chiefly prevailed were, founding upon piling carried up to about the level of low water, constructing within

caissons or coffer-dams, or building under water by means of diving apparatus. Instances of the failure of the first of these methods, which was believed to be inapplicable where there were marine worms, were given. The second was most effectual, but was generally expensive, and often attended with danger. The last was also costly, besides being subject to delay in the progress of the works. In bridge building of late years, the plan of forming enclosures of close piling, of the shape of the pier, and filling in with hydraulic concrete, had been pursued by French engineers; and the substitution of iron for perishable timber piling, in the construction on this plan of the piers of the Chelsea and Westminster bridges, by Mr. Page (M. Inst. C. E.), was considered to be a successful departure from stereotyped rules.

Although the value of beton, or hydraulic concrete, was now appreciated in this country as a substitute for masonry, and had been employed in some important works, yet its use was chiefly confined to forming a homogeneous and monolithic bearing stratum for foundations, and not, properly speaking, as a constructive material. The modes in which concrete had been applied for constructive purposes were, building it dry in mass, and allowing it to set before being placed in the work, as had been adopted in the construction of the walls of the Victoria and of the London Docks; preparing it first in blocks, and allowing it to harden before being used as employed at the Dover breakwater, and for the new sea forts at Portsmouth and Plymouth: and depositing it in a liquid state, and allowing it to set under water, as practised at the Government Graving Docks at Toulon. The facilities for making beton, which had the invaluable property of setting under water, and of thus forming an artificial rock or stone, were very great; as it might be made either from the naturally hydraulic limes, the artificially hydraulic limes, or cement, or from the rich or non-hydraulic limes, rendered hydraulic by the admixture of other substances, such as Puzzolana, minion, or iron mine dust. Various examples were adduced of the application of concrete, on a large scale, prepared from these different materials, especially at the Mole of Algiers, at the breakwater at Marseilles, and at other French ports, as well as in the Pont d'Alma over the Seine, in which case both the arches and the piers were formed of rubble concrete.

As Engineers-in-chief for the new harbor works for the port of Greenock, the author and his partner, Mr. Bell, had an opportunity of introducing a system of constructing sea walls and quays in deep water, without the aid of coffer dams, diving apparatus, or other means equally expensive. These works were situated on the west side of the town, and had been projected almost entirely beyond the high water line into the sea. The outer pier would ultimately be upwards of 3000 ft. in length and about 60 feet wide at the top, with quays on both sides. Within this there would be space for two harbors, each 1000 ft. in length, 15 ft. deep at low water, and 25 ft. at high water, with entrances 100 ft. wide, and ample room for the construction of graving docks, for the storage of timber, and for the erection of sheds. At present it was only proposed to erect about one-half of the sea pier,

and to form one harbor or tidal dock. In the design of these works, it was suggested that the walls under low water should consist of a combination of cast iron guide piles in the front, with a continuous stone facing, slid down over and enclosing these piles, timber-bearing piles being used in the body of the walls where required, and concrete backing being deposited in a soft state; and that the upper part of the walls should be built of masonry in the usual manner. The first operation, when the water was not sufficiently deep, was to dredge two parallel trenches to the required depth, 17 feet below low water, for the foundations. A staging of timber piles was afterwards erected in the line of the pier over its whole breadth, for carrying the tramways traveling cranes, and piling engines. The cast iron guide piles were then driven from the staging, with great precision, 7 feet apart in the line of the face of each quay wall. These piles were driven until their heads were near to the low water line, by pile engines, furnished with long arms projecting downwards, strongly stayed by diagonals, and forming a trough, into which the pile was placed, and from which it was shot, like an arrow from a cross-bow. The piles were connected at the top transversely by wrought iron tie-rods stretching through the pier. When the piling was driven, a bed of hydraulic concrete, 3 feet thick and 20 feet wide, was deposited in the trenches to form a base for the wall, and to give a large bearing surface. Into the grooves formed by the flanches of the iron piles, large granite slabs from the Ross of Mull, from 18 inches to 2 feet thick, were slipped, the bottom one resting on the concrete base, and on a projecting web cast on the piles. This constituted the face of the wall, and in each compartment between the piles, 16 feet in height and 7 feet in width, there were only three stones. Behind this facing hydraulic concrete was lowered, under low water, in large boxes having movable bottoms, and was discharged in mass to form the body of the wall. To confine this at the back before it had set, loose rubble stones were deposited. The hearting of the pier consisted of hard till, stones, and granite up to the level of low water. When the whole of this mass was consolidated, the heads of the iron piles and the granite facing blocks were capped by a granite blocking or string-course, and the upper portion of the walls was built in freestone ashlar and rubble. The remainder of the hearting between the walls was then filled in, and the whole finished with a granite coping and causeway. The walls were 33 feet in height from the foundations, 11½ feet thick at the concrete base, diminished by 5 feet at the top. In the part of the work already executed, the outer flanch of the iron piles was exposed to the action of the salt water. In future it was intended to reverse this plan, and to make grooves in the stone facing, so that it should overlap the iron piles, filling in the grooves from the top with cement. When the whole extent of the seaward pier was completed, the interior operations for the harbor would be proceeded with; this pier serving as the principal coffer dam, and a short dam, about 100 ft. in length, closing the entrance. It was stated that this method of constructing walls in deep water without coffer dams had been most successful, and that a sea-pier of great solidity

and durability had been formed in deep water at a comparatively moderate cost. The works of the Albert Harbor were being executed under the superintendence of Mr. John Thompson, as resident engineer, by Messrs. W. & J. York, contractors.

The application of this system to the construction of breakwaters and harbors of refuge, was then noticed, reference being first made to the principal modes of construction hitherto adopted, and to the peculiar phenomena by which such structures were affected. The usual method of forming breakwaters was by the *pierre perdu*, or long slope system, as carried out at Plymouth, Cherbourg, and Holyhead. Where stone was most abundant, a vertical wall was built from the bottom by means of diving apparatus, of which the breakwater at Dover, now in course of construction, was the most prominent example. Besides these systems, which might be taken as the extremes, an intermediate form of section, combining both, that was to say, a rubble mound to a certain depth under low water, and a vertical wall above, had been carried out at Alderney. From an examination of the general principles which affected breakwaters, and the modes of construction usually adopted, the conclusion arrived at was, that the vertical system was that which had best resisted, or rather averted, the destructive action of the sea, and required the smallest amount of material. Both the long-slope and the vertical systems, as at present carried out, were expensive, from the quantity of material used in the one case, and the costliness of the material and the mode of construction in the other; the former might be characterized as involving the maximum in quantity, and the minimum in cost of material; the latter, on the contrary, the minimum in quantity, and the maximum in cost of material. The object sought to be attained in the new system was to effect a minimum, as far as possible, both in the quantity and in the cost of the material. Breakwaters might be thus constructed, either wholly vertical from the bottom, or partially vertical, springing from a rubble mound. The principal feature of the new plan was a framework of iron piles, or standards, and ties, which would serve during the construction as the staging, and would afterwards form an essential portion of the structure, by binding together a strong casing of stone, or other sufficiently durable material, which would enclose and form the facing of the breakwater, the interior being filled up with loose rubble, cemented into a solid mass by liquid concrete. As soon as a pair of piles transversely had been fixed, rubble would be deposited up to, say, 18 feet under low water. Strong casing blocks, either of stone or of *beton*, made to enclose the iron standards, would then be lowered, the blocks being locked or arched into each other, so as to resist pressure from behind, and made to break bond, if thought desirable. The hearting of the work would be proceeded with simultaneously with the building of the casing, and would consist of rubble in the centre, and of hydraulic concrete behind the stone casing. It was believed that such a structure could be erected in a depth of 6 fathoms, with a range of tide of 15 feet, for £190 per lineal yard, without a parapet, and at £200 per lineal yard, including a parapet. The economy of this sys-

tem would arise from the smallness in quantity and the cheapness of the bulk of the material. It would also possess the advantage of rapid execution, as the mass of the material could be deposited without any tedious operation being necessary over a great length of the work at one time.

The author was of opinion that the system which had been described admitted of being applied for the construction of the works under low water, of marine fortifications, as well as of breakwaters, piers, quay-walls, lighthouses, and other similar structures. He considered that, although the mode of constructing an engineering work must be determined greatly by local circumstances, this system presented the following advantages: great economy, combined with strength and durability; facility and rapidity of execution; and adaptability to situations where the present modes of construction would be inapplicable.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Notes of Shipbuilding and the Construction of Machinery in New York and vicinity.

(Continued from p. 348.)

The Steamer George Washington.—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Pusey, Jones & Co., Wilmington, Delaware. Route of service, New York to New Orleans. Owners, H. B. Cromwell & Co., New York.

Hull.—Length on deck, 180 ft. Breadth of beam, 39 ft. Depth of hold, 11 ft. Do. to spar-deck, 18 ft. 6 ins. Draft of water, 15 ft. 6 ins. Frames—molded, 13 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, brig. Tonnage, 1256 tons.

Engines.—Vertical direct. Diameter of cylinders, 45 ins. Length of stroke of piston, 4 ft. 6 ins.

Boilers.—One—tubular—located in hold; does not use blowers. Has water bottom.

Propeller.—Diameter, 13 ft. 6 ins. Pitch, 19 ft. Blades, 4. Material, cast iron.

Remarks.—This vessel is constructed of white oak, chestnut, &c., and square fastened with copper and treenails. Around her frames, which are filled in solid, iron straps, double and diagonally laid, $3\frac{1}{2}$ by $\frac{5}{8}$ inches, extends, making them very secure. There is also a head strap of iron of the same dimensions placed around the head of frames. Under both decks knees are placed; her bunkers are of wood, and she has water-ways on both decks. She is supplied with one independent steam fire and bilge pump, and fitted with bilge injections and bottom valves. She has an independent rudder post, and cabin on deck. The whole construction of the *George Washington* is highly creditable to the skill of Messrs. Roosevelt, Joyce & Co., and gives great satisfaction to her owners.

The Steamer Mary Powell.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co., N.Y. Route of service, New York to Newburgh. Owners, A. L. Anderson & Co.

Hull.—Length on deck, 267 ft. Breadth of beam, 25 ft. Depth of hold, 9 ft. Draft of water, 5 ft. 3 ins. Frames—molded, 14 ins.—sided, 4 ins.—apart at centres, 12 ins. Tonnage, 796 tons.

Engines.—Vertical beam. Diameter of cylinder, 62 ins. Length of stroke of piston, 12 ft.

Boilers.—Two—flued—located on guards, uses blowers to her furnaces. Have water bottoms.

Paddle Wheels.—Diameter, 30 ft. Material, iron and wood.

Remarks.—This steamer is of white oak, chestnut, &c., and square fastened with iron and treenails. Her bunkers are of wood; she has one independent steam fire and bilge pump, one bilge injection, and two smoke pipes. Upon her promenade deck is a saloon cabin. The *Mary Powell* is an excellent river steamer, quite fast, and very comfortable, and is well liked upon her present route.

The Steamer Pomona.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co. Route of service, New York to Staten Island. Owners, North Shore Staten Island Ferry Co.

Hull.—Length on deck, 190 ft. Breadth of beam, 27 ft. Depth of hold, 9 ft. Draft of water, 6 ft. Frames—molded, 12 ins.—sided, 8 ins.—apart at centres, 24 ins. Tonnage, 500 tons.

Engines.—Vertical beam. Diameter of cylinder, 44 ins. Length of stroke of piston, 10 ft.

Boilers.—One—flue—located in hold; uses a blower to her furnaces. Has no water bottom.

Paddle Wheels.—Diameter, 26 ft. Material, wood.

Remarks.—This steamer is of white oak and chestnut, and cross fastened with composition metal and treenails. Her bunkers are of wood, and she has one smoke pipe. Upon the route of her present service, she has given much satisfaction.

The Steamer Fah-Kee.—Hull built by E. F. Williams, Greenpoint, L. I. Machinery constructed by Pusey, Jones & Co., Wilmington, Del. Route of service, New York to Hilton Head, S. C. Owners, Adams' Express Company, New York.

Hull.—Length on deck, 175 ft. Breadth of beam, 30 ft. Depth of hold, 10 ft. 6 ins. Do. to spar-deck, 18 ft. Draft of water, 14 ft. 6 ins. Frames—molded, 14 ins.—sided, 9 ins.—apart at centres, 25 ins. Rig, brigantine. Tonnage, 750 tons.

Engines.—Vertical direct. Diameter of cylinders, 42 ins. Length of stroke of piston, 3 ft. 6 ins.

Boilers.—One—tubular—located in hold; does not use blowers. Has water bottom.

Propeller.—Diameter, 11 ft. 6 ins. Pitch, 17 ft. Blades, 4. Material, cast iron.

Remarks.—This steamer is built of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are filled in solid under engine, and around them extends iron straps, double and diagonally laid, $3\frac{1}{2}$ by $\frac{1}{2}$ inches, also, a head strap of iron, 5 by $\frac{3}{4}$ inches, extends around the head of frames, making them very secure and of great strength. The model of this vessel is very handsome; her lines are graceful, and betoken speed. She was designed and built for service on the coast of China, but her present owners noting her beauty and admirable cargo-carrying capacity, purchased her to run as a

mail and express steamer to Hilton Head. Her bunkers are of wood; she is coppered, has one independent steam fire and bilge pump, bilge injections, bottom valves or cocks to all openings in bottom, and two bulkheads. Mr. Williams is entitled to much praise for the execution of this beautiful work of marine art.

The Steamer John Taylor.—Hull built by Barnard & Giles, Albany, N. Y. Machinery constructed by Jas. McGinnis, New York. Route of service, New York to Albany. Owners, New York and Albany Propeller Line.

Hull.—Length on deck, 205 ft. Breadth of beam, 38 ft. Depth of hold, 9 ft. Draft of water, 8 ft. Frames—molded, 15 ins.—sided, 7 ins.—apart at centres, 16 ins. Tonnage, 660 tons.

Engines.—Vertical geared. Diameter of cylinder, 36 ins. Length of stroke of piston. 3 ft. 8 ins.

Boilers.—Two—return flue—located in hold; use blowers to furnaces. No water bottoms.

Propeller.—Diameter, 11 ft. Pitch, 16 ft. Material, cast iron.

Remarks.—This vessel is of white oak, &c., and square fastened with galvanized iron. She has hanging knees, one independent steam fire and bilge pump, one bilge injection, bunkers of wood, and two smoke pipes. The *John Taylor* is a good boat, and gives satisfaction to all connected with her.

The Steamer Escort.—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed and vessel owned by James Murphy & Co. (Fulton Iron Works), New York.

Hull.—Length on deck, 190 ft. Breadth of beam, 27 ft. 9 ins. Depth of hold, 9 ft. 6 ins. Draft of water, 5 ft. 3 ins. Frames—molded, 14 ins.—sided, 9 ins.—apart at centres, 24 ins. Tonnage, 480 tons.

Engines.—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 10 ft.

Boilers.—One—tubular—located in hold; does not use blowers.

Paddle Wheels.—Diameter, 30 ft. Material, wood.

Remarks.—This steamer is built of white oak, &c., and fastened with treenails, &c. She has one independent steam fire and bilge pump, one bilge injection; bunkers of wood, and her water-wheel guards are sponsoned. The *Escort* is well built, and will do excellent service upon whatever route of duty she is placed.

The Steamer Oriole.—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, George Greenman & Co.

Hull.—Length on deck, 125 ft. Breadth of beam, 26 ft. Depth of hold, 7 ft. Draft of water, 6 ft. 6 ins. Frames—molded, 11 ins.—sided, 9 ins.—apart at centres, 24 ins. Rig, schooner. Tonnage, 210 tons.

Engines.—Vibrating lever. Diameter of cylinders, 20 ins. Length of stroke of piston, 18 ins.

Boilers.—One—tubular—located in hold; uses a blower to furnaces. Has water bottom.

Propeller.—Diameter, 4 ft. Pitch, 12 ft. Blades, 4. Material, cast iron.

Remarks.—This vessel is of white oak, &c., and square fastened with copper and treenails. Her frames are filled in solid under engines, and they are braced with straps, making them very secure. She is supplied with one independent steam fire and bilge pump, fitted with one bilge injection, and all necessary cocks. Her water-ways are of pine, and she has knees under main deck. In every respect this steamer is well built.

The Steamer Sze-Chuen.—Hull built by Lawrence & Foulks, Greenpoint, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. Route of service, coast of China. Owners, P. S. Forbes & Co., New York.

Hull.—Length on deck, 210 ft. Breadth of beam, 33 ft. Depth of hold, 11 ft. Do. to spar deck, 18 ft. Draft of water, 11 ft. Frames—molded, 16 ins.—sided, 6 ins.—apart at centres, 26 ins. Rig, brigantine. Tonnage, 1090 tons.

Engines.—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke of piston, 6 ft.

Boilers.—Two—flue—located in hold; does not use blowers. Have water bottoms.

Propeller.—Diameter, 10 ft. 6 ins. Pitch, 21 ft. Blades, 3. Material, cast iron.

Remarks.—This steamer is of white oak, chestnut, and hacmetac, and square fastened with copper and treenails. Her frames are strengthened and rendered very secure by iron straps, double and diagonally laid, $3\frac{1}{2}$ by $\frac{3}{8}$ inches, running around them. Her model is excellent, and her easy and graceful lines betoken speed. The manner of the construction of this vessel reflects much credit upon her builders, and gives great satisfaction to her owners. She has knees under both spar and main decks, water-ways of pine, bunkers of iron, one smoke pipe, one independent steam fire and bilge pump, one bilge injection, bottom valves to all openings in her bottom, and four ports for receiving and delivering cargoes. It is fair to surmise that the *Sze-Chuen* will be very popular upon the route of her service on the great Yang-tsze River, and thus be the means of spreading still further the names of her enterprising owners.

The Steamer Excelsior.—Hull built by F. V. Tucker, Red Hook, L. I. Machinery constructed by H. Esler & Co., Brooklyn, L. I. Route of service, Hudson River. Owners, Howland & Frothingham, New York.

Hull.—Length on deck, 190 ft. Breadth of beam, 22 ft. Depth of hold, 10 ft. Draft of water, 8 ft. Frames—molded, 15 ins.—sided, 10 ins.—apart at centres, 25 ins. Tonnage, 410 tons.

Engines.—Vertical beam. Diameter of cylinders, 18 ins. Length of stroke of piston, 18 ins.

Boilers.—Two—tubular—located in hold; do not use blowers. Have water bottoms.

Propeller.—Diameter, 6 ft. Pitch, 13 ft. Material, cast iron.

Remarks.—This boat is of white oak, &c., and well fastened. She has one independent steam fire and bilge pump, and one smoke pipe.

The Steamer Monohassetts.—Hull built by Thos. Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Route of service, New Bedford to Edgartown. Owners, New Bedford and Edgartown S. B. Company.

Hull.—Length on deck, 180 ft. Breadth of beam, 25 ft. Depth of hold, 9 ft. 6 ins. Draft of water, 5 ft. 3 ins. Frames—molded, 13 ins.—sided, 8 ins.—apart at centres, 23 ins. Tonnage 450 tons.

Engines.—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 10 ft.

Boilers.—One—flue—located in hold; uses a blower to furnaces. No water bottom.

Paddle Wheels.—Diameter, 27 ft. Material, wood and iron.

Remarks.—This steamer is built of white oak, chestnut, &c., and is well fastened in the usual manner. She has one independent steam fire and bilge pump, one bilge injection, one smoke pipe, bunkers of wood, and a saloon cabin on her promenade deck. It is thought that this vessel will meet the requirements of the route between New Bedford and Edgartown, and give general satisfaction.

The Steamer Morning Star.—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Allaire Works, New York. Route of service, New York, New Orleans, and Havana. Owners, New York Mail Steamship Company.

Hull.—Length of keel, 275 ft. Do, on deck, 286 ft. Breadth of beam, 38 ft. Depth of hold, 15 ft. 3 ins. Do. to spar deck, 23 ft. Draft of water, 14 ft. Frames—molded, 15 ins.—sided, 12 to 15 ins.—apart at centres 30 ins. Tonnage, 2000 tons.

Engines.—Vertical beam. Diameter of cylinder, 80 ins. Length of stroke of piston, 12 ft.

Boilers.—Two—return tubular—located in hold; uses a blower to furnaces. Have water bottoms.

Paddle Wheels.—Diameter, 33 ft. Number of blades, 28. Material, iron.

Remarks.—This vessel is of extraordinary strength; her materials of construction being live oak, white oak, hacmetac, and locust. Her fastenings are of the most approved character. The frames of this steamer are filled in solid, and secured with iron straps double and diagonally laid, $3\frac{1}{2}$ by $\frac{5}{8}$ inches. She has knees under both decks, water-ways of oak and white pine, one independent steam fire and bilge pump, one bilge injection, and bottom valves or cocks to all openings in her bottom. The *Morning Star* is the first of a line of steamships destined to ply between New York and New Orleans, *via* Havana, belonging to the company above named, of which Mr. John Raynor is President. She has very superior accommodations for passengers, all of the state rooms being of large size, and lighted and ventilated in the most perfect manner, while the height between decks gives to the saloons and state rooms an air of comfort and luxury as well as fitness for occupancy in warm climates. There are two hundred and twenty-three berths in the state rooms of the first cabin, and twenty-four berths in the second cabin. The cabins are painted in pure white, relieved with pink and gold. Recently this steamer went on her trial trip, extending to a point some twenty-five miles outside of Sandy Hook, which resulted with complete satisfaction to her owners and builders. So well pleased were the gentlemen accompanying her, that they held a meeting in her main saloon and unanimously passed the following resolutions:

Resolved, That the New York Mail Steamship Company are entitled to the thanks of the citizens of New York, for the addition of this splended steamship to the commercial marine of the metropolis.

Resolved, That in this successful trial trip of this magnificent vessel, we see the augury of the success of the enterprise, and we congratulate the owners on the prospect before them.

Resolved, That the gratitude, especially of the merchants of New York, is due to Mr. John Raynor, President, and Mr. John Egerton, Vice-President, and Mr. Robert J. Hubbard the Secretary of the Company, and to the Directors thereof, for the efficient and successful establishment of this new line of commercial steamers.

Resolved, That in the construction of this vessel in these times, in the breadth and completeness of its arrangements, we recognise the extension of our national prosperity, and the vigor of individual enterprise.

Resolved, That the builders of the hull, engines, and all those who furnished the other equipments, have accomplished all that lay in their different departments to render this vessel worthy of the patronage of the traveling community.

The Steamer Che-Kiang.—Hull built by Henry Steers, Greenpoint, L. I. Machinery constructed by Morgan Iron Works, New York. Route of service, coast of China. Owners, Russell & Co.

Hull.—Length on deck, 260 ft. Breadth of beam, 36 ft. Depth of hold 14 ft. Draft of water, 8 ft. Frames—molded, 15 ins.—sided, 10 ins.—apart at centres, 26 ins. Rig, Brigantine. Tonnage, 1266 tons.

Engines.—Vertical beam. Diameter of cylinder, 70 ins. Length of stroke of piston, 11 ft.

Boilers.—Two—tubular—located in hold; do not use blowers. Have water bottoms.

Paddle Wheels.—Diameter 30 ft. Material, iron.

Remarks.—This steamer is of white oak, chestnut, locust, &c., and fastend in the most approved manner. The frames of this vessel are not filled in solid, but they have iron straps, double and diagonally laid, 4 by $\frac{5}{8}$ inches, extending around them, and a head strap of like metal around head of frames, 6 by $\frac{3}{4}$ inches, rendering them very secure. She has one independent steam fire and bilge pump, one bilge injection, one smoke pipe, and knees under main deck. The *Che-Kiang* is of handsome model, and in her every particular she is constructed with the one idea of making her a vessel second to none of her class. I trust that her career on the coast of the Celestial Empire will prove prosperous.

The Steamer Tillie.—Hull built by C. S. Bushnell, New Haven, Conn. Machinery constructed by C. H. Delamater, New York. In Government service. Owners, N. L. & J. L. Griswold & Co., New York.

Hull.—Length on deck, 146 ft. Breadth of beam, 26 ft. Depth of hold, 9 ft. Do. to spar deck, 16 ft. 6 ins. Draft of water, 10 ft. Frames—molded, 11 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, schooner. Tonnage, 463 tons.

Engines.—Horizontal. Diameter of cylinders, 20 ins. Length of stroke of piston, 17 ins.

Boilers.—One—tubular—located in hold; does not use blowers. Has water bottom.

Propeller.—Diameter, 10 ft. Pitch, 16 ft. Blades, 4. Material,

Remarks.—This vessel is built of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are filled in solid under engine, and have double and diagonally laid iron straps, $3\frac{1}{2}$ by $\frac{1}{2}$ inches, running around them. She has an independent steam

fire and bilge pump, one bilge injection, one smoke pipe, and waterways of white pine.

The Steamer Hamilton.—Hull built by Webb & Bell, Greenpoint, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. Route of service, New York to Brooklyn. Owners, Union Ferry Company.

Hull.—Length on deck, 160 ft. Breadth of beam, 32 ft. Depth of hold, 12 ft. 6 ins. Draft of water, 6 ft. 6 ins. Frames—molded, 13 ins.—sided, 6 ins.—apart at centres, 23 ins. Tonnage, 509 tons.

Engines.—Inclined. Diameter of cylinder, 38 ins. Length of stroke of piston, 10 ft.

Boilers.—One—flue—located in hold; does not use blowers. No water bottom.

Paddle Wheels.—Diameter, 16 ft. Material, wood and iron.

Remarks.—This vessel is of white oak, &c., and fastened in the securest manner. It is filled in solid at both ends, the peculiar service of the boats belonging to this company demanding vessels of this character.

The Steamboat La Bonita.—Hull built by H. L. Bushe, Greenpoint, L. I. Machinery constructed by Fulton Iron Works, New York. Superintendent of construction, Chas. H. Haswell, New York. Route of service, Guatemala, C. A. Owners, Guatemala Company.

Hull.—Length on deck, 42 ft. Breadth of beam, 9 ft. Depth of hold, 2 ft. 11 ins. Draft of water, 12 ins. Tonnage, $9\frac{67}{95}$ tons.

Engine.—Inclined. Diameter of cylinders, 8 ins. Length of stroke of piston 12 ins.

Boiler.—One—tubular.

Paddle-Wheels.—Diameter, 7 ft. 10 ins. Material, iron.

Remarks.—This marine dwarf is of corrugated iron, $\frac{1}{16}$th of an inch in thickness, well fastened and admirably put together. Her boiler is furnished with all the gauges, &c., necessary to make it complete. She is supplied with an independent steam fire and bilge pump.

The construction of this vessel is an initiatory step in an enterprise believed to be pregnant with profitable return, not only to her originators, but all connected with her in her future career. She is intended as the pioneer vessel of the Guatemala Company, an association of wealth and enterprise formed in New York, having for its ultimate design, the opening of an entensive trade in the province of Guatemala, Central America, consisting in the cutting and shipping to the United States of pitch-pine timber, forests of which exist there. That this business may be prosecuted with its deserved success, the Directors of the Company have organized an efficient body of operators, and appointed as their general director and superintendent, a Mr. J. A. DeBrame, a gentleman of ability, and one possessing the necessary administrative ability, it is believed for such a position. Mr. De Brame recently left New York with his men and the little steamboat for the scene of their future labors. They went well provided with the engines, saw-mills, tools, &c., requisite for the various manipulations to be gone through with, before their article of trade is ready for shipment and market. I trust that success will attend this movement of the Guatemala Company, and that in the end they will be richly repaid for the energy they have in this wise made manifest.

On the trial trip of the *La Bonita*, her boiler worked well, making ample steam, and she was worked up to thirty revolutions per minute, making some 7¼ knots per hour. This trip satisfactorily proved that even such a little steamer could be built, and worked successfully. B.

New York, May 13th, 1863.

The Trisection of an Angle. By JOHN O'DONOGHUE.

To the Editor of the Journal of the Franklin Institute.

I beg to offer you the following remarks on the trisection of an angle:

This problem, simple as it may appear to be, has engaged the attention of the greatest mathematicians that ever existed. After a long and laborious investigation, Sir Isaac Newton, among the rest, so completely failed in his attempt to solve it on pure geometrical principles, that he declared it impossible for any person to trisect an angle within the limits of pure geometry. It certainly is a most difficult problem, and involves a cubic equation. Hence it requires conic sections and the higher order of mathematics for its solution, if we confine ourselves to the three postulates laid down by Euclid as the basis of all geometry.

Yet simple as these postulates are, still in drawing lines and describing circles we bring to our aid mechanical instruments, such as the ruler and divider. Now, if I am allowed to add another mechanical contrivance to these, with which to describe a curve, I can easily trisect an angle. I see no reason why I should be denied this privilege, when I find such men as Legendre, Davies, and a host of others, not only adding to the number of Euclid's postulates, but changing the order of his books, and not strictly adhering to his propositions.

In order to explain the use of this instrument which I desire to add to the ruler and divider in trisecting an angle, let us premise the following:

Let ABDC be a rectangular parallelogram, having the side DB double of the side CD or AB. Trisect CD, and let DR be double of CR. Now, I want to describe a curve (fig. 1) passing through the points R and B, and having this property, that a line drawn from the point D to any point in the curve shall be double the perpendicular let fall from that point on the line AC.

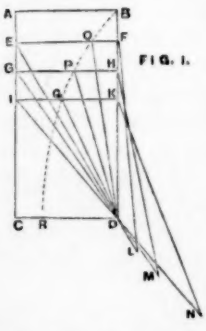


FIG. 1.

Take any number of points, E, G, I, &c., infinitely near one another in AC, and through these points draw the lines EF, GH, IK, &c., parallel to AB or CD, meeting BD in F, H, and K. Join also ED, GD, ID, &c. Take also the distance BD in your dividers, and from the points F, H, K, &c., as centres, describe arcs cutting ED, GD, ID, &c., produced in L, M, N, &c.; hence FL, HM, KN, &c., are each equal BD, and therefore doubles of FE, GH, IK, &c. Through D now draw the lines DO, DP, DQ, &c., respectively parallel to FL, HM, KN, &c.

By similar triangles we have now FL : FE :: DO : OE; but FL is twice FE, therefore DO is double OE. In the same manner it can be proved that DP is double PG, DQ double QI, &c. Now, through the points B, O, P, Q, R, &c., draw the curve BOPQR, and this curve will be such that a line drawn from its focus D to any point in the curve will be double the perpendicular let fall from that point on the line AC.

Now, this method of tracing curves by finding several points in the periphery, and of afterwards connecting them so as to preserve the regularity of the form of the curve, is more a mechanical than a geometrical method of describing them. Hence, to avoid this objection, we make use of the following contrivance for constructing this same curve. It is, I consider, as purely elementary as a pair of dividers are, and no person objects to the use of these in describing circles. Seeing no reason then why a curve described by a pair of dividers should be considered elementary and purely geometrical, while curves described by other instruments are not accepted as such, I have therefore no hesitation in pronouncing the following curve as purely geometrical as the circle is.

Let D be the focus of the curve, R its vertex, join RD, and produce it to C, making CR equal to one-half of RD, and erect CA perpendicular to CD.

Now take a carpenter's square, and place one of its sides on AC (fig. 2), the other side will fall in the direction AB perpendicular to AC. Again, tie one end of a thread to one side of the eye of a needle, and run the thread (after passing it round a small pin or roller fixed in the side AB of the square) through the eye itself.

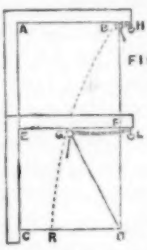


FIG. 2.

Then, after making the whole length of the thread equal to twice HA, or making the part DB of the thread equal to twice AB, fasten the other end in the point D. Now move the square, sliding the side AC along the line AC, and keeping the needle upright and close to the side AB of the square. The eye end of the needle, while the side AB of the square moves from the position AB to the position CD, will describe the curve BGR (supposing the thread to wind freely over the pin or roller and the needle kept close to the side of the square during the operation), having this property.

A line drawn from the focus to any point in the curve will be double the perpendicular let fall from that point on the line AC.

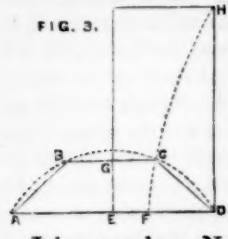
This is evident from the construction and the figure. But perhaps the following observations will make it plainer. The whole length of the thread was made equal to twice HA, but that part of the thread from the eye of the needle winding round the pin and back to the eye again is just twice HB; therefore the remainder DB of the thread is equal to twice BA, the perpendicular let fall from the point B on AC.

Again, when the side AB of the square comes to the position EL, then the whole thread will be double of LE; but that portion of the thread from the eye G to the pin L being doubled, is twice GL, therefore the remainder DG is also double the remainder EG. Q. E. D.

To apply this curve to the trisection of an angle.

Let ABCD (fig. 3) be any arc of a circle, and let AD be its chord; bisect AD in E, and from E erect EG perpendicular to AD; then EG if produced would pass through the centre of the arc. Trisect the line ED in F, and then DF is equal twice FE. From D as a focus and F as a vertex, describe the curve FCH by either of the above methods, cutting the arc ABCD in C; from C let fall the perpendicular CG, and produce it to meet the arc ABCD again in B. I say the arc ABCD is trisected in C and B.

FIG. 3.



Join DC and AB. Now, because CB and DA are both perpendicular to EG, they are parallel to one another. Again, as BC and DA are two parallel chords, the chords AB and CD joining their adjacent extremities are equal. And because EG passing through the centre cuts CB at right angles, CB is bisected in G. Hence, BC is double of CG. But by the properties of the curve, DC is double of CG, for the line drawn from the focus D to any point C in the curve is double the perpendicular let fall from that point on the line EG. Therefore BC and DC being each double of CG are equal. But I proved DC to be equal to AB. Hence the three chords DC, CB, and AB are all equal, and therefore the three arcs DC, CB, and BA are also equal. And as equal angles stand on equal arcs, the whole angle at the centre will be trisected by lines joining the centre to the points B and C in the circumference.

Should this be not considered strictly geometrical, still its publication will enable the mechanic and engineer to trisect an angle with mathematical accuracy in a simple and practical manner.

Though others have trisected an angle before now, yet they did not pretend to have done it within the limits of geometry, but made use of conic sections and the higher order of mathematics.

Therefore I think my mode of handling this problem new, and my solution purely geometrical. At all events, my manner of treating it is simple and easily understood, and if allowed the same latitude that some writers on geometry are, I have no doubt of having succeeded. I will be at all times ready to remove any objections that may be raised against it, and receive the criticisms of any geometer as a personal favor.

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We publish the above article on account of its ingenuity and because it bears unmistakable evidence of original thought. But the writer is mistaken in thinking that he has avoided Conic Sections, for his curve is a hyperbola, and the trisection of an angle by means of the hyperbola was demonstrated by Pappus, although in an entirely different manner. (See *Montucla, Quadrature du Cercle*, p. 243.) It may also be worth while to protest that Newton's assertion that an angle could not be trisected except by the uses of curves of the higher orders, was founded not only on his failures to solve the problem otherwise, but on a mathematical demonstration of the impossibility. EDITOR.

On a Plea for Cotton and for Industry. Lecture by THOMAS BAZLEY, Esq., M. P.

[Before the Royal Institution of Great Britain, May, 30, 1862.]

From Newton's London Journal, September, 1862.

The fact of the cotton trade in this country being dependent chiefly upon one source of supply for its raw material, has been at all times the cause of anxious solicitude to the thoughtful observer of the nation's progress; but the dilemma in which that great industry is now placed by that sole dependence deserves the consideration alike of the statesman, of the economist, of the merchant, of the employers of labor, and of the humane and patriotic public. Between cotton and labor, there was formed in Lancashire, three-quarters of a century ago, an alliance which, combining mechanical with manufacturing skill, has created an industry unparalleled in any other country.

Little more than a century since, the clothing comforts of the masses of the people were few in this country, and the abundant luxuries which now prevail were to them almost unknown. The prepared skins of animals were, up to that recent date, largely used in the clothing of the peasant, and in every house and hamlet the distaff and spindle, and the weaving loom, ministered to the supply of linens, woolens, and their mixture, in aid of domestic wants. In the reign of Elizabeth, her subjects were only equal in number to the inhabitants of Lancashire and Yorkshire at the present time, and greatly below the people of those two counties, with Cheshire added. The British people under Elizabeth were powerful, and in splendor and position ranked with the highest nations of the earth; yet her army, navy, aristocracy, court, and people, did not exceed that portion of Queen Victoria's subjects, who directly and indirectly subsist upon the toils, industry, and capital of the cotton trade. The kingdoms of Belgium, Portugal, Holland, and Hanover do not separately contain populations as extensive as the cotton trade supports in Great Britain; hence this industry of five millions of dependents, sustained by no separate regal power, and hitherto happy and prosperous as a portion of the subjects of our gracious Sovereign, may claim to be at least of some national importance. About three centuries ago, the whole people of this country might be equal to the five millions who now subsist by the manipulations, products, and commerce of cotton; but at this moment the population of the United Kingdom may be regarded as thirty millions, yet the same circumscribed and limited extent of land only exists to afford them the means of labor, and to yield them its fruits which supported their predecessors. Even in Elizabeth's reign, the people were deemed to be too numerous for the extent of land in her British dominions, and restrictions upon the building of dwellings in proportion to the areas of districts were enacted. If, therefore, the augmentation within the period now mentioned, of from five to thirty millions of people, be considered, it is self-evident that new sources of industry have had to be developed to supply increasing wants.

Mineral and agricultural products, in past ages, furnished scanty exports to pay for foreign articles of necessity and luxury; but, with a constantly increasing population, the yield of the soil has been absorbed by the large consumption at home; and now foreign supplies of corn, of other food, and of luxuries, are required for, and may be equal to the subsistence of one-third of the entire population of the United Kingdom. But whilst supplies of food have been needed for this increasing population, the other concomitants of comfort have also been required, and all these necessaries of life could only be obtained in this country by the magic power of skill and labor.

A sea-girt land with navigable rivers, thus possessing egress and ingress, seems to invite foreign intercourse, and to be the first essential to a great mercantile and manufacturing district; but when such a country is found to be immeasurably rich in its mines of coals and metals, when it possesses a temperate and healthy clime, and, above all, when its inhabitants are hardy, sagacious, toil-loving, free, and untiring, we may infer that the decree of Providence has ordained that the people with these advantages shall be blest with plenty, and shall contribute of their abundance to the families of mankind. To no country, however, has exclusive advantages been given; but, wisely, mutual dependence appears to be the pacific bond intended to promote the welfare of the common brotherhood. Probably beyond every other people, the British possess the elements of successful trading and commercial industry; but beyond the direct necessaries of life, which their labor ought to enable them to buy, they need raw materials whereon that labor can be employed. Sheep's wool and flax, Great Britain can, in part, produce towards the demand for them; but still large quantities of them are required from foreign countries, and silk, cotton, and other productions of the warmer regions must always be imported as contributions in aid of the manufacturing industry of the United Kingdom. Textile fabrics afford in their production the most extensive means of employment, and have become the indispensable clothing comforts of the people of every country. The fabrics and manufactures of cotton are, however, among the most useful, convenient, elegant, and economical productions of labor. From the quilt or bed-cover to the finest and most filmy muslins—from the fustian garments of the poor to the decorations of lace worn by the rich—and in the snow-white gift of the bleacher to the rainbow colors of the printer—cotton is prolific of comfort and ornament.

The persecutions of the Duke of Alva had banished from their homes the Flemish weavers, who took refuge in Britain. These skilful and ingenious workmen became valuable acquisitions in a country commencing the transition from the labors of the field to those of the loom; and the domestic manufactures of our country began to indicate the progress and perfection which they were destined to attain. The dawn of a great industry was perceptible. Industry was honored, and labor inculcated as the foundation of the nation's coming distinction and prosperity. Even more than two centuries ago, when steam engines were unknown, canals not having been formed, nor large manu-

facturing establishments erected, and while deer-forests surrounded this vast city, there were merchants who promulgated sound economical principles, and who taught lessons of wisdom to the possessors of regal power. In London, in 1641, Roberts, a son of commerce, published an enlightened pamphlet, entitled "Treasures of Traffic," and in proof of the soundness of his views, the following extract cannot fail of being interesting and welcome. He said,—"Some princes are not satisfied with those materials that grow among themselves, and in their own countries, but they covet by all industry to draw others from their neighbors, or foreign nations, to employ their subjects, and to put their people on work, by this means much enriching themselves, and honoring their country; and adding a great help to the public traffic thereof, selling and venting them thus wrought, even to those nations who many times have sold and furnished them with the very first materials of the said manufactories." "Manchester in Lancashire, must also herein be remembered, and worthily, and for their industry commended, who buy yarn of the Irish in great quantity, and weaving it, return the same again in linen, to Ireland to sell. Neither doth the industry rest here, for they buy cotton wool in London, that comes first from Cyprus and Smyrna, and at home work the same, and perfect it into fustians, vermilions, dimities, and such other stuffs, and then return it to London, where the same is vented and sold, and not seldom sent to foreign ports." Thus at a period in English history when Charles the First was surrounded with troubles, discord and distress prevailing, Roberts, in beautiful simplicity of language, uttered the first plea for cotton and for its industry, thereby throwing a lustre upon his own name and upon the seventeenth century.

In the middle of the eighteenth century, a considerable home manufacture had arisen. Cotton was spun by hand, and afterwards blended in the loom with linen or woolen, thus producing a mixed fabric. The supply of cotton was then inconsiderable, and was obtained from Turkey and the Levant, and from the West Indies. Mechanical science now escaped from the libraries and traditions of the learned, and offered practical aid to the infant industry. Such a galaxy of talent and inventive genius as then stood forth to develop new methods of increasing the comforts both of the palace and of the cottage, the world had not seen. By an almost mysterious combination of efforts, Hargreaves, Whyatt, Arkwright, and Crompton were devising their several systems of spinning cotton; Watt was rendering available the majestic power of vapor, directing, controlling, and dooming it to become the universal drudge of man; Scheele and Berthollet, with their oxygenated muriatic acid, blanched the calico and the cambric; and the Mauvillions, Nixons, and Peels gave their colored tints to print these new fabrics; and as if inspired by the inventions which sprang from the east of the Atlantic, the Anglo-Saxon in the United States of America originated the cultivation of cotton in that great territory: but in giving this boon, by the production of slave labor, he conferred the bane whence the vast cotton industry now suffers, in the deprivations inflicted upon labor and capital. In the year 1700, when me-

chanical appliances were comparatively unknown in the manufacture of cotton, the consumption of this material might be one million pounds weight; but in 1860, the quantity had culminated in the consumption of one thousand millions pounds weight in that year. Cotton began to arrive from America in 1787, in sufficient quantity to prove the power of the States to produce it, and in that year Crompton triumphed over his mechanical difficulties and completed the mule,—this machine being the great agent at the present time for the production of coarse as well as of fine yarns; but spinning by rollers, and Arkwright's throstle spinning frame, had been invented twenty years previously; hence the history of the modern and mechanical cotton trade may be dated from this period.

Eighty years ago the cotton industry of our country was thus initiated, and from that time to the present, progress, improvements, and extension have characterized it. The science, skill, and invention which have accompanied its development are wonderful. It has afforded employment, comfort, and prosperity to many millions of the people of this country during that period, and it has contributed very largely to the national revenue. During the great struggle with the first Napoleon, our men were able to leave their country for the strife of war, and yet the steam engine and the mechanical agencies which existed at home more than compensated for their physical loss; but here was the waste of the nation's strength. Wiser would it have been had these new resources been developed for the moral, mental, and social improvement and comfort of the people at large. Most probably the cotton trade and the development of new mechanical powers, have enabled the people of this country to sustain a system of taxation which, without that trade and those treasures, could not have been borne, and have supported a national expenditure alike extravagant and injurious. The state, therefore, has participated in the contributions of all who have promoted and sustained this industrial fabric.

The capitalists of this trade have now two hundred million pounds sterling invested in it, in fixed and floating property; and the people directly and indirectly employed in it being now five millions, we arrive at the important deduction that not only does the national exchequer derive great benefit from it, but we have capitalists and laborers supported by it as numerous as are the people of several European kingdoms of the present time. Indifferent spectators of the abundance which has happily prevailed in this country since the introduction of the liberal commercial policy which is now established, rarely reflect upon the obligations this vast industry has conferred in aid of the elements of social comfort. Of late years, the exports in cotton manufactures have been about fifty millions sterling per annum, or about one-third of the gross exports of the United Kingdom. Well, then, as cotton exports constitute one-third of the whole, it becomes evident that cotton buys one-third of the imports; hence, as gold, silver, gems, coffee, tea, sugar, tobacco, wine, oil, and the fruits of sunny climes, as well as corn and other food brought hither, are foreign products largely imported into the United Kingdom, we must claim the

merit for the cotton trade of having bought and paid for one-third of these exotic and foreign supplies. In 1860, the last year of active and full employment for the whole of the cotton trade, its manufactured products exceeded eighty millions sterling in value, something more than fifty of which were exported, leaving about thirty millions as the value of the home consumption of cotton manufactures; but as this latter sum will about equal the cost of the raw cotton imported, the beneficial interest of the country in the cotton industry will be represented by its export trade of upwards of fifty millions sterling. That so extensive and prosperous an industry should have been founded upon the supply of a foreign product, is not the least wonderful fact of its history; but that cotton should have been almost exclusively, as it has been, obtained from almost adverse sources, is a great reproach to the British nation.

Of the 2,523,000 bags of cotton consumed in this country in the year 1860, 85 per cent. consisted of the growth of the United States, 8 per cent. of the growth of Egypt, Brazil, and other foreign districts; whilst of cotton from the British East and West Indies the consumption was only 7 per cent.! In consequence of the convulsion in the States of America, the consumption of cotton in Great Britain, in 1861, resulting from its contracted supply and the loss of the American markets for its manufactured products, diminished 10 per cent.; and whilst of American and other foreign cotton the consumption became only 85 per cent. against 93 per cent. in the previous year, the consumption of East Indian cotton was 15 per cent. against the previous 7 per cent.; but of the present diminished consumption probably 75 per cent. may be East Indian. A very rapid increase has been effected in the consumption of East India cotton, which, in 1860, was 3500 bags per week, in 1861, 7000 bags, and in this year is proceeding at the rate of 15,000 bags, or more, per week, showing the increase to be 100 per cent. per annum upon each successive year. The actual power of consuming cotton in the United Kingdom is 55,000 bags per week; but, lacking the requisite supply, the present total consumption cannot exceed 25,00 bags per week.

Such, then, having been the rise, progress, productive and consuming power of the cotton trade, are we blameless for allowing this immense industry to exist and extend upon the frail basis of slavery upon which it has largely depended?

How fearful is the contemplation of a people, whose labors, directed by intelligence and right principles, having supported them with abundance, and still able and willing to work, being deprived of the material on which their industry has been advantageously engaged? The deprivations in this great industry have become lamentably severe. With less then half a supply of raw material, and at the enhanced cost of a whole supply, only half employment can be afforded, and consequently only half wages, or less, can be earned. Already the working classes of the cotton trade are subjected to diminished earnings of 4 million pounds sterling per month. Generally, the mills are working half-time, but many are wholly stopped, whilst a very few con-

tinue to give full employment, but the average time now worked will be the half-time now stated; and the consumption of cotton is only 25,000 bags weekly instead of the 55,000 bags capable of being consumed; but in this latter quantity is included the probable consumption of many new mills which have not begun to work. Of the consumption of cotton at the present moment, the East Indies supply 75 per cent., 12½ per cent. is America, and 12½ per cent. other foreign kinds. Last year the East Indies were exhausted of the stocks of cotton usually held there, and it is doubtful whether the million bales then received can be repeated this year. No efforts to obtain cotton from new fields, commensurate with the necessity, are being made.

In 1848 Mr. Bright, M. P. for Birmingham, proved by his parliamentary committee the capability of the East Indies to grow and supply abundantly most excellent cotton. With many men of experience, I gave evidence before that committee; but apathy in the Government, in the trade, and in the public mind, has caused to be neglected the admonitory facts then elicited.

Essentially, Great Britain possesses the monopoly of the best land found in the world for the growth of cotton. In the East Indies, the policy, under the rule of a nominally commercial company, has been absurdly political and despotic. The material prosperity of the people was neglected; navigation, by improving the rivers, has been discouraged; few canals have been formed; roads have scarcely existed; ample means for irrigation have been withheld; quays are almost unknown; and the land held by Government feudal power has been largely unproductive. By the small water supplies of Colonel Sir Arthur Cotton, immense benefits have been derived in Madras, and by the recent changes in land tenure, great improvements will doubtless result. Railways are now being established, and the general indications of the great dependency are becoming favorable for the extension of cotton and other agriculture, and for trade and commerce. For many years the improved navigation of the Godavery has been a subject of contention and of hope deferred. This river ought to connect the great cotton-fields of Berar with Coringa and other ports in Madras. The rocky barriers of the Godavery should be either removed, or they should be avoided by the aid of short links of canals, or by tramways. To what extent the works of the Godavery have proceeded we are ignorant, but the advantages which would accrue from their completion cannot be overstated. Its fertile valley would yield immense supplies of excellent cotton and other products; the markets to ten or twelve millions of people being opened would yield double advantages, alike to a home and a foreign trade. On the banks of that river, at Ingelhaut, cotton of most acceptable quality to the British spinner is already grown; and in its vicinity, as also in Berar, cottons could be cultivated which would equal, if they did not surpass, the productions of New Orleans. Of the power of the East Indies to produce superabundant supplies of most excellent cotton, no doubt need be entertained. The communications within the vast dependency being effectively extended to its sea-board in every direction, its agriculture

being industriously conducted by the aid of practical science, and the government of it becoming wise and just, benefits would flow from and to it, fructifying and enriching the whole empire. In 1860, the imports of cotton from the East Indies were 561,200 bags, of which two-thirds were exported, and in 1861 there came 986,600 bags, or nearly double the previous year's supply; but though the importers of this enlarged import have derived very great profits by the advance which has taken place in the price of cotton, the ryot, or farmer, in India, has not yet importantly obtained any advantage from the increased value of his produce; but if the communication with the interior of India, both as to intelligence and the conveyance of cotton, be facilitated, then the ryot will be stimulated by compensating and increased rewards, to extend the cultivation of cotton, and to improve the quality of it. As now stated, ample proof exists that India can grow most excellent cotton, and many supplies of very useful qualities have been thence received; and I now have the satisfaction of placing before this meeting a sample of superior cotton sent by Dr. Short, from Chingleput, in Madras. I am also enabled to display some very good yarns, of above the average fineness, being 60s. warp and 80s. weft, spun from it by Mr. Kirkpatrick, at his mills near Manchester.

A Cotton Supply Association was formed in Manchester a few years ago, and its labors are constantly directed to obtain corrective measures for the evils of India, and to promote the growth of cotton wherever the soil and climate of any country will enable it to be produced. This association has impelled a wiser policy for India, and has rendered valuable services to that dependency and to other countries; having made grants to upwards of 400 places of cotton seeds and of cleaning gins, besides other agricultural implements. By the exertions of this body, small supplies of cotton have been received from many new fields of cultivation. Cotton-growing is being slowly resumed in the British West Indies, whence encouraging supplies are now received; but if the proprietors of estates in those islands did their duty to themselves and to their country, an enlarged production of excellent cotton would compensate them and contribute to the nation's prosperity. The fine island of Jamacia, which could produce very large quantities of superior cotton, is a territorial wreck; but see the capability of this island by this sample of cloth made from its cotton. Demerara, and other neighboring possessions, can produce more cotton than the United Kingdom could manufacture. From the Cape of Good Hope to Port Natal cotton can be abundantly produced. Africa has of late years sent small, but valuable supplies of cotton, of qualities quite equal to the produce of New Orleans; but her Egyptian cotton has, from the time of Mehemet Ali to the present moment, been a large and most welcome contribution. If the million per annum, which our fleet for the suppression of slavery costs, had been devoted in our own colonies, or even in Africa, to the encouragement of the growth of cotton, sugar, and other products, which the labor of the negro in slavery has yielded, then that disgraceful traffic in human beings might have been annihi-

lated, and our own pursuits untainted with the wrongs inflicted upon the colored race. Australia, however, has amazing powers for the production of cotton, and in sections of that great country—Queensland, Victoria, and New South Wales—cotton of every class, from the lowest to the highest, might be cultivated and produced beyond the wants of all the world. Queensland has sent small lots of cotton of unsurpassed beauty and excellence, and from this colony, and from New South Wales, samples of cotton may be seen in the great International Exhibition of qualities adapted to the production of the finest muslins and laces which any skill could manipulate, as may be seen by this beautiful specimen of lace made from it. Labor appears to be almost alone the sole requisite for obtaining supplies of cotton of incalculable extent from Australia. On referring to the cultivation of cotton in America, we learn that there one million of negroes can produce cotton of nearly twice the extent of its consumption in Great Britain, consequently half a million of laborers would suffice to produce the cotton needed by the latter; and the question arises whether it would not be an act of prudence and of wisdom to induce this number of Chinese men, women, and children to become cotton-growing laborers in Australia. In the States of America, only about one-quarter of the negro population is there engaged in cotton agriculture, the large majority being employed in producing tobacco, rice, sugar, Indian corn, and in handicraft and domestic pursuits or occupations. The Emperor of France has wisely offered great inducements for the growth of cotton in Algiers, whence very superior cotton is already supplied. That French colony is within a single week's sail of this country, and some eminent men of business here and in France are endeavoring to extend the cultivation of cotton in it, which, if judiciously carried out, cannot fail to become of vast advantage to all the relations of both countries.

With these facts, the power abundantly to produce cotton, not only in British possessions, but in many foreign states, is beyond all doubt.

By the general neglect of cotton agriculture, an aggregation of evils now exists which can only be contemplated with profound grief and apprehension. Probably 100,000 laborers, who have usually shared the employment afforded in the cotton trade, are now totally idle and penniless. 300,000 more are working short time, and in the sympathetic branches much deprivation prevails. The losses of the laboring classes are one million pounds sterling per month, or twelve millions per annum; whilst the employing classes are, by loss of rents, interest of money on stagnant capital, and in suspended operations, without computing anything for loss of profit, sustaining a loss equal to eight millions per annum, thus making the certain loss in labor and capital, into twenty millions sterling per annum; but the great infliction of double price for cotton, which adds eighteen millions per annum to its normal market cost, subjects the trade to a drain of nearly forty millions per annum, and to an exhaustion tending almost to extermination. Cotton-spinning and manufacturing in Great Britain, are equal in extent to those pursuits carried on in America, and upon the continent of Europe. Consequently, in the British and foreign cotton

trades, the losses and disadvantages will be double the extent stated for this country alone. A plea, then, for cotton and for industry becomes a duty and a necessity.

Seeing, therefore, the extent of distress existing in the districts of the cotton manufacture, and that increased deprivations may inflict deeper misery upon the laboring classes, whilst many capitalists may be on the verge of total ruin, and seeing also that the people of the United Kingdom generally sympathize with the sufferings in the cotton trade, what assistance can be rendered to this apparently decaying industry is a question that many benevolent individuals will ask. Will not the British Government and people best remove present and future evils by assisting to develop the resources of their colonies, which, by the introduction of cotton cultivation upon a large scale, would be rendered productive and prosperous?

Shall no attempts, commensurate with the wants of this great industry, be made to obtain adequate supplies of cotton, and at the same time to benefit the dependencies and colonies of Great Britain? No charity can compensate for the losses now sustained, and effectual relief can only proceed from an abundant supply of good and cheap cotton.

A moral truth has now been taught the world—that slavery and tyranny shall not permanently yield prosperity; and the wrongs of the oppressed crying for justice, indicate that retribution is the corrective of iniquity. Experience and the physical construction of the earth both tell us that without adequate exertions there can be no beneficial result; and consequently, in this great country, when dangers are threatening extinction to any portion of the community, efforts must be called forth to sustain the social and industrial fabric, to contribute to the means of labor, to promote commerce, to extend civilization, and still to raise our national aims in the cause of humanity and of universal justice; that should prosperity again shine upon our country, there may be, in our distant intercourse and relations, no leading into captivity, and at home no complaining in our streets.

Association for the Prevention of Steam Boiler Explosions, Manchester.

From the Journal of the Society of Arts, No. 520.

At the meeting of the Executive Committee, held on Tuesday, October 28th, 1862, the chief engineer presented his monthly report, of which the following is an abstract:—

During the past month there have been examined 353 engines and 539 boilers. Of the latter 9 have been examined specially, 9 internally, 48 thoroughly, 473 externally, in which the following defects have been found:—Fracture, 7 (1 dangerous); corrosion, 30 (3 dangerous); saftey-valves out of order, 15; water gauges ditto, 7; pressure gauges ditto, 20; feed apparatus ditto, 7; blow-off cocks ditto, 27; furnaces out of shape ditto, 3; blistered plates, 5. Total, 121

(4 dangerous). Boilers without glass water gauges, 8; without pressure gauges, 7; without blow-off cocks, 18; without back pressure valves, 50.

Three explosions have occurred during the past month to boilers not under the inspection of the Association; these boilers were in the iron districts, and of the externally-fired haystack class; they were reported as having been of original defective construction, being insufficiently stayed. One of these explosions was attended with fatal consequences, the engineman being killed.

Incrustation and Scum Pipes.—The number of boilers under inspection which suffers from incrustation is very large; indeed, to escape this inconvenience is quite exceptional. It forms a considerable impediment to satisfactory inspection, since it renders it difficult to ascertain the actual condition of the plates; it sometimes gives a delusive appearance, and leads to undue suspicion of corrosion, but more frequently it conceals defects, since corrosion is often found to be going on under and to be caused by the deposit.

In addition to the waste of fuel occasioned by incrustation, the wear and tear of boilers is considerably increased, apart from the effects of over-heating. Thus internally double-flued boilers suffer from the undue longitudinal expansion given to the furnace crowns, which increase the tendency to groove at the front end plate, an action always more or less developed in these boilers, while incrustation renders the use of tubular boilers altogether impracticable in localities not supplied with good water, and thus prevents the more general use of this economical class of boiler.

Although the danger of allowing incrustation to form on plates exposed to the action of the fire is too fully appreciated to need remark, the fact is not so fully recognised that even where no actual cake of deposit is formed, over-heating frequently occurs. It is thought that this may, in many cases, be due to the presence of thickening matter held in suspension in the water, and it would be interesting to ascertain by experiment whether the impediment thus presented to the free escape of the steam does not—where the circulation is imperfect, or no such agitation of the boiler takes place as in locomotives when running—lift the water off the plates, and thus cause overheating. Of the fact of overheating occurring where no incrustation is formed, and with an ample supply of water in the boiler at the time, there is no doubt instances are constantly coming under notice, and it may be added that they are chiefly found to take place in boilers externally fired.

Apart from the injury done to the boilers from incrustation, a considerable amount of earthy matter passes over with the steam into the engines, and thus renders necessary the use of an increased amount of tallow for the piston and slides. This, though too frequently lost sight of, is illustrated by the fact that where boilers are fed from brooks, subject, on heavy rains, to sudden torrents which stir up the mud, the engine attendants are in the habit, at such times, of taking the pre-

caution of giving the engine cylinders an extra amount of lubrication, finding the pistons, &c., to clog when this is neglected.

Under ordinary circumstances, the most practical plan for the prevention of incrustation is the adoption of an efficient mode of "blowing-out," and not the use of "boiler compositions." To blow out, however, from one point only, at the bottom of the boiler, which is the general custom, has but a very limited and local effect. This is frequently remedied by the adoption of a perforated pipe, which is connected to the ordinary blow-out tap, and carried along the bottom of the boiler from one end to the other. These are technically termed "Topham-pipes," from the name of the patentee, and are generally spoken highly of by those of our members who have adopted them. They are, however, more successful where the sediment being heavy and sludgy falls to the bottom, than where it is of a lighter character, which frequently forms the hardest and most tenacious scale.

From the rapid ebullition that takes place within boilers when under steam, it is found that a greater part, if not the whole, of the sediment set free by evaporation, rises to the top of the water, forming a coat of scum, before finally depositing itself upon the furnace tubes or shell; and thus the readiest way of preventing incrustation is to blow out this layer of scum from the surface of the water by means of a scum pipe, before it has an opportunity of settling. There is nothing new or experimental in this; the system has been for years adopted with marine boilers, and there is no reason why its use should not become equally general with stationary ones. Many of our members have already tried it with considerable success, and find, on opening their boilers after a month or six weeks work, that where they used formerly to be coated with a heavy muddy deposit, they are now perfectly clean.

The following is an explanation of the description of pipe adopted: It is about three or four inches in diameter, having a wing cast to it on each side, so as to form a trough throughout the entire length of the pipe. This pipe is carried within the boiler, from one end to the other, being made in any convenient lengths for introduction at the manhole; it is perforated with small holes on the top all the way along, the aggregate area of the whole number of these holes being equal to that of the pipe itself. The top of the trough is fixed a few inches below the level of the water, so that the scum on the surface may flow over it, when, being guarded from the disturbance of the ebullition, it deposits in the still water above the trough the sedimentary particles held by it in mechanical combination. A tap is fixed to the front end plate of the boiler, in communication with this pipe, by means of which it can be blown out as frequently as is desired, which should not be less than once every two hours, when ebullition is going on. This tap, which need not be more than two inches in diameter, should be entirely of brass, fitted with a gland, and have a neat waste pipe attached, which may be of wrought iron, while also the waste pipes from the glass water gauges may be connected to it, being led immediately under the dead plate, which arrangement is found to be very compact

and convenient. The best position for the scum pipe is at the side, and not at the centre of the boiler, both on account of facility in fixing, and convenience of getting inside. A single pipe is sufficient.

The above description is not by any means given as if that were the only form of scum pipe that could be advantageously applied. It was designed for the use of the members as being adapted to stationary boilers, simple in construction, affording a large collection area, and being free from any patent right. Upwards of a year's trial has proved it to be successful, and its more general adoption is consequently recommended. These pipes have already been made by the manufacturing engineers of Rochdale, Bolton, Bury, and other places, but are needed more generally, and a drawing at the office is open to inspection for the benefit of the members.

There are other plans in operation which, however, are subject to patent right. One of these consists of a series of vertical pipes, fixed in the centre of the boiler, each pipe having a trumpet mouth, to which a vertical telescope movement is given, to allow for the changes of water-level, the movement being effected by a copper ball float, so that the trumpet mouth rises and falls on the changes of water-level, like a buoy on the rise and fall of the tide; the object being to keep the mouth of the pipe immediately below the surface of the water, in close proximity to the scum. A second plan consists of a trumpet mouth laid horizontally. Both of these arrangements are reported to give satisfaction, and, whenever opportunity offers, the results of their working will be noted, and particulars of the plan found to be most successful communicated to the members.

Some descriptions of incrustation, however, cannot be entirely removed by any blowing-out apparatus alone, however perfect; in such cases a little carbonate of soda may be added, which many of our members have applied with considerable success. Of the use of this, their experience is decidedly in favor, while the testimony with regard to complicated "boiler compositions" generally, is that they found them expensive, in many cases useless, in other injurious, and have, in the majority of instances, discontinued them altogether. For fuller chemical particulars refer to Dr. Angus Smith's report to the Executive Committee upon the Incrustation in Boilers. The use of soda, without a scum pipe, is found in some cases to induce priming; the soda combining with the grease within the boiler, and producing foaming of the water.

The general adoption of scum pipes is, therefore, confidently recommended to the members, not only for the prevention of incrustation, but also, in order to lengthen the lives of their boilers, as well as to assist the engines in many cases, by preventing priming.

The most radical cure for the prevention of incrustation, though one involving considerably more outlay at the first than the above, will be found in the adoption of dry or "surface condensation," by means of which the boiler is fed with distilled water, the same being used again and again, with the exception of the slight amount lost through leakage. To those who are paying large amounts annually for a supply

of town's water, and where the steam is consumed for engine purposes, the adoption of surface condensers is well worthy of serious consideration, not only on account of the saving in the water rates, but also in that of fuel, since non-condensing engines may, by this means, be converted into condensing, which is not at present generally the case where town's water is used.

Results of an Experimental Inquiry into the Comparative Tensile Strength and other Properties of various kinds of Wrought Iron and Steel. By Mr. DAVID KIRKALDY.

(Continued from page 317.)

From the Mechanics' Magazine, January, 1863.

In the discussion which followed—

Mr. Walter McFarlane said it was well known to all practical workers in steel and iron, that if they attempted to temper some kinds of steel articles in water they cracked; but that if they did the same thing in oil there was not the same danger of doing so. He did not know whether Mr. Kirkaldy had given, or could now give an explanation of the cause of the increased strength of steel when tempered in oil, as compared with that tempered in water? He would like to know whether the fibre altered, or what tended to produce the result.

Dr. Macquorn Rankine remarked that Mr. Kirkaldy disavowed in his book any attempt to explain the changes which took place in steel when plunged into water or into oil.

Mr. McFarlane said he thought there was an absolute necessity for their getting at the cause of that important result.

Mr. Kirkaldy in answer to the president, had nothing further to say upon the point.

Mr. D. More said that Mr. Kirkaldy invited "special attention to the practical use that may be made of the new mode of comparison introduced by him, viz: the *breaking strain per square inch of the* fractured *area of the specimen, instead of the breaking strain per square inch of the* original *area.*" That seemed to be the principal point hinged upon, as it was given in *italics.* Now he did not think it was even the breaking strain of the *fractured* area that must be considered, for after the iron was broken it drew out a little further. This sort of posterior action was shown in some experiments made by Dr. Rankine and himself in regard to iron and also brick. They found, in crushing the brick, that it withstood a considerable force, and afterwards crumbled away with a less force, thus showing that the breakage had really taken place before the brick had commenced to crumble away. In experimenting with an iron bar, it was observed that the iron drew out and became narrower at one part (as he showed by a sketch on the board) until the strength of the material was overcome. Then, immediately on the iron beginning to break, it drew out before it was finally completely separated, so that the fracture took place when the bar was a little bigger than it finally became. He thought

that the truth lay between the two areas—the original and the fractured area.

Mr. Kirkaldy said he had given the stretched area also in his tables, so that parties could judge for themselves. The three areas were given—the original, the stretched, and the fractured areas.

Mr. W. M. Neilson remarked that Mr. Kirkaldy's book was a mass of *data* from which to deduce results. He thought it was a very excellent thing that Mr. Kirkaldy had confined himself to giving facts, which would cause his book to be much more relied upon. He believed that Mr. Kirkaldy wished to lay his facts before the Institution for discussion, and that he would not be displeased, although they pulled them about as they liked. Regarding the effects of frost upon iron, upon which point he had never himself been quite clear, it appeared that frost did not affect the strength in a direct strain; but he had always had an idea, that perhaps not the drawing strain, but the breaking strain, was very much affected by frost. They all knew the fear they had of using chains in frosty weather. Now, he supposed that the strength of the chain links was very much diminished by the frost, and that the links broke not so much by direct tension as by a breaking strain.

Mr. Kirkaldy said his experiments on the influence of frost were all made with specimens taken from one bar. He regretted that the weather changed before he could carry out his intention of repeating those experiments with bars of various qualities. As the bar experimented upon happened to be of very good quality, perhaps they ought not to draw general conclusions from its behavior.

Mr. W. Simons said that in the operations attending upon the placing of a thousand-ton ship on a ship dock, during one frosty night, he had seen three rods 3½ ins. in diameter, broken, so that they had to stop and put fires to all the rods and joints, and after that none of the rods broke. In the International Exhibition, he had observed a very good specimen of Swedish iron, which some of the other members might also have seen, which was all crumpled like a hat, it being the bow of a steamer after collision. He did not believe that any Scotch iron would have stood such a test. He was of opinion that the result of Mr. Kirkaldy's investigations would be, that the present system of shipbuilding would be found to be entirely erroneous, and that for the future iron would be used in shipbuilding with its longitudinal fibre placed in the direction of the most constant strain, a principle which had hitherto been ignored in marine construction.

Mr. B. Connor said that some very interesting experiments, which had not been published, had been recently made by Messrs. Naylor and Vickers, at Sheffield, with a view of testing steel, so as to ascertain the best suited for railway axles and tyres. They had found that the material best suited for axles was the worst for standing great tension. They found that steel, which could bear only 35 tons of tension, was the best for journals. They tried steel with 15 cwt. falling from 1 ft. up to 36 ft. The tensional strength of the steel was then increased so as to stand up to 69 or 70 tons, but it broke with the

weight falling one-third of the space, and with less than one-half of the weight; and so that that which stood the greatest tension broke with the least concussion. He thought that between the highest and the lowest qualities of steel there was only a difference of one-fourth per cent. of carbon.

Mr. Kirkaldy thought that these experiments supplied strong reasons for taking the stretched and fractured areas into account.

Mr. B. Connor did not think the steel with the greatest amount of carbon, that broke almost short off, would show nearly so great a difference between the fractured and the original areas as the soft steel.

Dr. Macquorn Rankine concurred in what Mr. W. M. Neilson had said as to the very valuable collection of facts, most of them entirely new, which Mr. Kirkaldy had given in his book. It was a store-house from which they could all draw materials, and form their own conclusions upon them. Mr. Kirkaldy had very fairly described those facts, and it was the better that he had not set up any hypothesis upon them. One of the particular things which he (Dr. Rankine) remarked was, that the experiments of Mr. Kirkaldy seemed to point to the conclusion, that a process which many supposed to take place, namely, a change from the fibrous to the crystalline structure, had no real existence; and that the same piece of iron would show a crystalline or fibrous appearance accordingly as it was broken by a stroke or a strain. He came to the same conclusion himself nineteen years ago by experimenting on the fracture of railway axles, which when fitted up seemed to have been quite strong enough. He collected the broken-off journals of such axles; but he was sorry he could not now produce them, as no means had been taken to prevent the ends getting rusty. But he had made full sized drawings, colored from nature, of the more remarkable of them, which he presented to the Institution of Civil Engineers, along with a paper, an abstract of which was published, but the drawings were not published, and remained at that Institution, where they could be seen by any one. He still, however, possessed the originals of those drawings; and if it would be agreeable to this Institution to see them, he would produce them at a future meeting. Of course they were not so satisfactory as the original specimens, or as Mr. Kirkaldy's; but unfortunately the originals had been spoiled by rust. He got the journals of axles that had run two or three years, and had then broken off spontaneously, and almost every one of these showed a fibrous fracture, with here and there a crystalline spot. There was invariably a crack which had eaten in from the shoulder of the journal, and which was perfectly imperceptible until after the fracture took place. The crack seemed to have gone on until it had reduced the original diameter of the journal to one-half, and then the axle snapped; but it always presented a fibrous fracture, whilst if the same journals were broken off with the blow of a hammer, they presented crystalline or granular fractures. Accordingly, he had ever since thought it probable that a change from fibrous to crystalline, as supposed, was an erroneous hypothesis; and he believed that many other persons had come to the same opinion, and he was glad that Mr. Kirkaldy's ex-

periments corroborated it. An important point in those experiments was the calling attention to the comparison between the fractured area and the load that caused the piece to give way. Every one knew before, that bars of iron would draw out, especially if soft, before giving way; but never before Mr. Kirkaldy had any one accurately measured the final area to compare that with the load. He thought that there was a great deal in the principle Mr. Kirkaldy laid down as to testing the quality of iron by the comparison of the breaking strain with the fractured area; but he would not go as far as Mr. Kirkaldy and say that it was the most accurate test, although he had no doubt it was better than comparing the original area with the breaking load. The experiments of Mr. Kirkaldy had substantiated results that had been anticipated by theory. For example, it was a result of theory that the form of the longitudinal section influenced the breaking load per inch of area. Experimentalists, however, had not taken that into consideration before. Experiments were made upon the tenacity of bars that were for a long distance of a uniform diameter, but there had been experiments made with bars shaped so as to have an increasing diameter on both sides of the middle part (as he had pointed out on the board), and the result was a great apparent increase of strength. It had been perfectly well understood by writers on the theory of elasticity, that the shape referred to must give apparent increased strength to the narrow portion of the area, as the wider parts on each side resisted the tendency to draw out, which was not the case with the parallel bar. Experimentalists, however, had not taken this into account until Mr. Kirkaldy took it up and arrived at the results detailed in his book. Mr. Kirkaldy showed that the resistance of steel rivets to shearing was about a quarter less than the tenacity of the steel. That, also, was anticipated by theory. There was one very important point upon which Mr. Kirkaldy made some remarks, namely, as to the factor of safety—the ratio in which the breaking load ought to exceed the working load. Mr. Kirkaldy considered that the working load per square inch of the original area of the piece should be a certain per centage of the breaking load per square inch of the contracted area at the instant of being broken. He (Dr. Rankine) concurred in Mr. More's opinion, that the truth lay between the extreme views. He thought it would be going rather too far to make the working load per square inch a certain fraction of the breaking load per square inch of the fractured area. He might call attention to experiments made on the strength of steel by Prof. Tresca, of the French Government Corps of Engineers. They were made upon bars of steel cut out of boiler plates, and they showed the gradual elongation of the bar with the gradual increase of the load. The results were represented by a curve (of a kind sketched on the board by Dr. Rankine), the abscisses of which represented the loads, whilst the ordinates represented the elongations due to the loads. It was found that as the load was increased, the elongation increased at a uniform rate, until it reached a certain point, when there occurred a great increase in the rate of elongation, which was not quite sudden, though nearly so; and there resulted a

curve, the early part of which proceeded in a nearly uniform direction, and which merged by a quick bend into a portion proceeding in a different direction corresponding to the more rapid elongation. Now, he thought the point where the change in the curve of elongation occurred was that at which the strength of the material had been overcome. It was very probable that the drawing out, which was so conspicuous in Mr. Kirkaldy's experiments, began at that point, and that the greatly increased curve of elongation showed that the breaking had begun, and that the bar would break if the same load was simply put on it several times, without being increased, as was seen in Mr. Fairbairn's experiments. The experiments of this class were very interesting, taken in connexion with Mr. Kirkaldy's experiments. He thought, then, that the best test of the quality of the material was the strain at which the sudden change of the curve of elongation began; or, if that supposition of his was right, the point at which the drawing out of the fibres commenced. If they could only make experiments so precisely as to measure the area of the bar at the instant of change, and compare it with the load, and take the corresponding strain per square inch, they would get at the true strength of the material; it would give a result between that of the old method and that of Mr. Kirkaldy's method. But although it was very desirable to obtain such experiments, yet there were difficulties in the way of performing them upon the immense number of materials that Mr. Kirkaldy had experimented upon. The Institution could not be too grateful to him for his labors, for he had collected a mass of facts which were of the highest value in a scientific and practical point of view.

Mr. James Russell would like to notice one proposition in Mr. Kirkaldy's treatise as to the appearances presented by the bar fractured when the fracture was made suddenly or slowly. It appeared that iron broken very slowly had a fibrous appearance, whilst that snapped off was crystalline. They all knew that if they wished to judge of the quality of iron in a rough way, they would break it probably over the anvil and look at the fibre. They found that bars broken in the same way presented very different appearances. They also found that some of the bars broken by Mr. Kirkaldy were half fibrous and half crystalline. Now, if the appearance of the fracture was no sure test of the quality of the iron, then they were put in a very awkward position as to judging of any iron that came under their notice to apply to various purposes. He dared say that it would agree with all their experience that iron had been judged by the appearance of the break. It was also known that a chain working on a crane might have sustained great loads for a long time, and yet break with a very much lower strain, and the broken link have a very crystalline appearance. A case came under his own notice where the top chain of a Derrick crane bore a heavy strain, and yet broke with a third of the weight that had been on it previously, and the link presented a very crystalline appearance. He hoped other members of the Institution would make a few observations on this important matter.

The President asked what was the state of the weather when the rod broke?

Mr. James Russell dared say they had seen them break in all kinds of weather; but uniformly when the link of a chain broke with a comparatively light load, it was more crystalline in appearance than other links that stood the test. For instance, they might take one bar and give it a blow, bending it only, whilst another would with the like blow, snap at once like cast iron. They were in the habit of saying that the one that bended was fibrous, and the one that snapped was crystalline.

Mr. Faulds could not look on a crane chain being broken with a third of its previous load as a criterion by which they could judge of the strength of iron, for a careless man by giving it a jerk would bring it down. But with reference to breaking iron, so as to appear fibrous or crystalline, any smith could take a bit of the best iron and break it, either crystalline or fibrous, as he chose.

Mr. W. Macfarlane would call attention to another phase of the question besides the quality of the material. They must not lose sight of the fact that some firms turned out better work than others, although using the same materials, and that induced him to call their attention to the annealing of iron. The strength of iron was very much reduced by the breaking of the skin, so that the strength of a finished shaft was less than when it left the forger's hands. In articles of great value, when the safety of many lives rested upon the security thereof, it occurred to him that it would be well if wrought iron were annealed. He would like to know whether any extensive producers of such articles had made experiments on the annealing of iron work; and, further, what would be the expense if turned shafts were annealed or tempered in oil. His impression was that the same results must follow as with cast steel, and that the strength of the material would be very much increased by the annealing or by the tempering process of oil—these two modes of treatment being quite different in their results.

Mr. Faulds had thought that the breaking of the skin weakened a bar of iron; but he understood Mr. Kirkaldy to say that a turned bar would stand as much strain as an unturned one.

Mr. R. B. Bell wished to call to Mr. Mcfarlane's attention the fact that Mr. Kirkaldy had drawn up these statistics from actual and accurately arranged experiments, so that what he had put forward were facts, not mere opinions or prejudices; and he would like to know if what Mr. Macfarlane stated was merely his opinion, or if he had made actual experiments with bars of equal sizes to ascertain this fact?

Mr. W. Macfarlane said it was from his own practical experience, but without making any special experiments to test the correctness of his deductions. His belief was that if the skin of an inch bar of cast iron were broken, it was weakened very much.

Mr. W. M. Neilson suggested that instead of "practical experience," perhaps Mr. Macfarlane should have said "practical prejudice."

Dr. Macquorn Rankine said he thought that no one would ques-

tion the greater strength of cast iron with the skin than without it; but as regarded wrought iron, he did not believe that there had been any precise experiments until Mr. Kirkaldy had made his. There was one matter about which there was no doubt; that if they had to turn a piece of wrought iron they ought to interrupt, as little as possible, the contiguity of the fibres; this was to be insured by forging it as nearly to the required shape as possible, so as to have little cross-cutting of the fibres. He had verified that doctrine at the time when he experimented with the axles, nineteen years ago.

The President said that the skin of all malleable iron was broken in bringing it into use, as in tyres, axles, &c.

Dr. Macquorn Rankine said that if they took two journals of the same diameter that had been turned alike, but which had been hammered down to different forms, although they were of the same dimensions, yet on account of the contiguity of the fibres in the one not being interrupted, it was stronger than the other in which the fibres were cut by the turning process.

Mr. Macfarlane said he hoped they would excuse him pressing upon them the importance of annealing important forgings. His own opinion was that it would materially strengthen them.

Mr. W. M. Neilson remarked that he thought what Mr. Macfarlane insisted on was, in other words, to make the iron more homogeneous.

Dr. Macquorn Rankine said there was one other fact of considerable importance that Mr. Kirkaldy brought out, which had been anticipated by theoretical writers, that the stretching of the metal tended to diminish its density.

Mr. R. B. Bell drew attention to the fact which Mr. Kirkaldy had made known, that galvanizing did not hurt the strength of iron in large sections; and he could add, that it did not do so in small ones, as had been proved in testing galvanized and ungalvanized wire ropes.

Mr. Macfarlane would like to know what process of galvanizing was referred to, as the one was a mechanical combination with the iron, while the other was chemical.

Mr. Kirkaldy said it was the chemical process.

Mr. W. Simons believed that, with reference to galvanized iron ropes, the result had been quite the opposite of that stated by Mr. Bell.

Dr. Macquorn Rankine said he had made experiments on that subject, and the result he came to was that the ungalvanized iron was, perhaps, a shade stronger, but the galvanized was more extensible. The result was, that what the galvanized rope wanted in tenacity, it more than made up by being more extensible, and it was, therefore, better able to resist a shock. The difference in tenacity, however, was so small, that it might have arisen from errors in the experiments. One peculiarity he had observed in galvanized wire was, that when a certain pull was put upon it, much of the elongation that took place was permanent. Perhaps that arose from the compression of the layer of zinc. The permanent elongation did not increase by repeated applications of the load, provided the load was within the limits of safety.

Mr. D. More asked if Mr. Macfarlane thought that if they annealed

forgings before they were finished it would add to their strength, or must they be annealed after being finished?

Mr. Macfarlane replied that they should be annealed when they came out of the forger's hands, but tempered after they were finished.

Mr. D. More asked—Would there not be some danger of the shaft getting warped?

Dr. Macquorn Rankine asked if Mr. Macfarlane intended them to be put into cold oil?

Mr. Mafarlane answered in the affirmative.

Mr. Faulds said that there would be a danger of twisting a shaft if it were annealed after being finished.

Mr. Macfarlane said that the strength would be increased, but admitted the danger of twisting.

The President then proposed the thanks of the Institution to Mr. Kirkaldy for bringing so valuable a series of experiments before them. He thought they would all agree with him, that the discussion should be adjourned, in order that members who were absent might have an opportunity of giving their views on that important subject, and also in order that they might have an opportunity of inspecting the drawings which Dr. Rankine had so handsomely offered to lay before them.

The vote of thanks was passed, and the discussion adjourned.

Statistics of Coal in Great Britain.

From Herapath's Railway Journal, No. 1227.

Mr. Hunt estimates that 83,635,214 tons of coal were raised in the United Kingdom last year. Of this amount Durham and Northumland, with 217 collieries, contributed 19,144,965 tons; Cumberland, with 28 collieries, 1,255,644 tons; Yorkshire, with 397 collieries, 9,374,600 tons; Derbyshire and Nottinghamshire, with 180 collieries, 5,116,319 tons; Leicestershire, with 11 collieries, 740,000 tons; Warwickshire, 16 collieries, 647,000 tons; Staffordshire and Worcestershire, with 580 collieries, 7,253,750 tons; Lancashire, with 373 collieries, 12,195,500 tons; Cheshire, with 39 collieries, 801,570 tons; Shropshire, with 66 collieries, 829,750 tons; Gloucestershire, Somersetshire, and Devonshire, with 112 collieries, 6,514,025 tons; Wales, with 398 collieries, 8,561,021 tons; Scotland, with 424 collieries, 11,081,000 tons; and Ireland, with 46 collieries, 123,070 tons. The coal production of the empire appears to have largely increased during the last eight years. Thus, in 1854, with 2397 collieries worked, 64,661,401 tons of coal were raised; in 1855, with 2613 collieries, 64,453,079 tons; in 1856, with 2829 collieries, 66,645,450 tons; in 1857, with 2867 collieries, 65,394,707 tons; in 1858, with 2958 collieries, 65,008,649 tons; in 1859, with 2949 collieries, 71,979,765 tons; in 1860, with 3009 collieries, 84,042,698 tons; and last year, with 3052 collieries 83,635,214 tons. Of this vast quantity, only 7,560,758 tons of coal, 286,150 tons of coke, and 79,017 tons of patent fuel were exported, the remainder being absorbed at home. France was last year our best customer for coal, having taken 1,436,160 tons (this year the exports

in the same direction have been somewhat reduced in consequence of the use of French coal for the Imperial navy); Denmark came next, with 542,567 tons; Hamburg, 514,427 tons; Prussia, 439,096 tons; Italy, 417,629 tons; Spain and the Canary Islands, 403,238 tons; America (Atlantic Ports), 349,931 tons; Russia (northern ports), 342,513 tons; the foreign West Indies, 262,932 tons; Holland, 262,868 tons; Sweden, 214,004 tons; British India (continental territories), 199,060 tons; Turkey, 174,686 tons; the British North American colonies, 165,824 tons; Brazil, 157,281 tons; Norway, 135,221 tons; the British West Indies, 127,768 tons; Malta, 115,731 tons; Portugal, the Azores, and Madeira, 108,794 tons; and Hanover 100,312 tons. Our other foreign customers took less than 100,000 tons each.—*Times.*

Wood Preserving Processes.

From the London Builder, No. 1050.

I have read with much interest the article in your journal entitled "Notes on the Properties of Wood." Noticing the importance you attach to the different processes for preserving wood, I make so bold as to offer you some data which have been arrived at in Belgium, Holland, and France, concerning their relative merits. It is quite true, as you say, that the continental engineers esteem the processes of English origin the most highly, and especially Mr. Bethell's creosoting process. The efficacy of the creosoting process has for some years been admitted in the most absolute manner by the engineers in the Netherlands, and no other wood preserving process is used by them. It has been proved in an equally absolute manner in Belgium by a series of experiments upon the principal wood preserving processes, made by the Belgian Government engineers. These experiments have lasted through a period of twelve years, and were conducted with the greatest care and vigilance. In the course of these experiments there were laid down creosoted sleepers, 223,654; sleepers prepared with sulphate of copper, 199,061; sleepers prepared by other processes, 25,730. And in 1860, *Compte Rendu des Opérations des Chemins de Fer Belges*, 1860," p. 28, the Minister of Public Works published his determination to prepare in future all railway sleepers with creosote, except the oak sleepers, which are not to be prepared at all. M. Crepin, a Belgian Government engineer, who has tried experiments upon the relative advantages of creosote and sulphate of copper for the preservation of timber in marine constructions from the attacks of worms, &c., has lately published a report, *Annales des Travaux Publics de Belgique*, tome 19, in which he states that creosoting is the only process he has found to succeed for this purpose. Indeed, he states that sulphate of copper affords no protection whatever against the action of salt water and marine insects.

As regards France, I must add that although immense quantities of timber prepared with sulphate of copper have been used by the French railways; nevertheless, there also, experience points to the

condemnation of this preservative. At the end of the last year, the committee of the Belgian engineers being unable to reconcile the facts they had observed in Belgium with the opinions of the French railway engineers, and fearing lest the failure of sulphate of copper in their experiments had been occasioned by some imperfection in their mode of employing it, the Belgian Minister of Public Works asked permission from the Nord and other railways of France for a committee of Belgian Government engineers to inspect the sleepers prepared with sulphate of copper and placed on the said railways in France. The result of the inspection made by the committee proved to them that no better results had been obtained in France than they had obtained in Belgium; and that consequently they had not to blame themselves for any want of skill in their application of the sulphate of copper process. It was quite by chance, through my being in London for a few days, that I came to read your article; and it is in the interest of truth alone that I send you the above facts, which I hope you will kindly place in your next number.

The Belgian Government now require that all the wood sleepers used in the state railways should be creosoted; and the Government of Holland have also made the same resolution; and upwards of 300,000 sleepers per annum are now being creosoted for the Dutch Government, and more by the Belgian Government. A. T., Antwerp.

On a New Chrome Green. By M. Mathieu Plessy.

From the London Chemical News, No. 166.

The following is my method of operating:—

In 10 parts of boiling water I dissolve 1 part of bichromate of potash; to this I add 3 litres of biphosphate of lime, then 1·250 kilogrammes of brown sugar.

After a little time a tumultuous disengagement of gas takes place, which must be moderated by sprinkling over the froth.

After calcination the whole is left to stand, and by the following day the green is deposited. The supernatant liquid, of the color of salts of chromium, decant, and wash the precipitate with cold water until the acid re-action ceases; it is then placed on a cloth, *essoré*, and taken to the stove.

The above quantities give 2·500 of product.

This green containing, as we have shown, no poisonous substance, is unalterable in the sun; sulphuretted hydrogen has no effect on it; acids, even though concentrated, do not destroy it, or, at least, act very slowly as solvents. In fixing it by albumen, and printing with it, there is no inconvenience, except a slight paleness of tint.

By the firm of Betremieux it has been used in printing on a plain paper ground, producing an agreeable water green color. As a smooth ground it has also been employed as an oil color at the Louvre, and the tint has remained unaltered since its application a year ago.—*Repertoire de Chimie Pure et Appliquée.*

Some Remarks upon Light. By Mr. B. S. Proctor.

Read before the Newcastle Microscopical Society, at the December meeting.

From the London Chemical News, No. 164.

As the paper was somewhat lengthy, and the points suggestive of discussion numerous, it was agreed to have the paper printed and distributed among the members previous to its discussion at the January meeting. The following is an abstract of its contents:—

The speaker commenced by remarking upon the transparency and brightness which are revealed by a microscopical examination of objects commonly said to be dull opaque white, and the translucency of so-called opaque bodies, of whatever color, if reduced to thin films. Such common-place observations, he said, had suggested to his mind a variety of questions, the elaboration of which formed the material of his paper. The first point considered was, whether the transparency of white materials was universal, and, if so, what was the difference between the white powders, such as carbonate of lead, which are said to have strong "body,"* and those which, like carbonate of magnesia, are wanting in this property. From the number of white powders which had been examined, all proving to have considerable transparency, it was inferred as a rule that, in white powders, pretty free transmission of light takes place through the individual particles.

The phenomena of body were explained and illustrated by the action of three bundles of glass plates, one being immersed in oil of turpentine, another in water, and the third being dry. The latter was shown to have most body in consequence of the great difference between the refractive power of the glass and the films of air intervening; but where a medium of refractive power approaching that of glass existed between the plates, much less reflection and more transmission took place; thus, magnesia, which appears to have considerable body while dry, loses it when mixed with oil, from their refracting powers being nearly equal. White lead retains its body when ground in oil, because of its refracting power being much higher than the oil. The difference in the body of precipitated coil-lead, and that made by the old process, was next explained by showing that where there was apparently equal comminution in the two, the particles of the precipitated carbonate consisted of clear crystals; while in the other variety the particles consisted of aggregations of smaller particles, each of which was transparent in itself, but in the aggregate was scarcely translucent.

The white surface of dead silver was next noticed, and the microscope showed that the light reflected from it consisted of mixed, not of combined colors.

The attention of the meeting was then drawn to the bearing some of these facts have upon the mounting of microscopic objects; for example, Tous-les-mois was shown mounted dry, mounted in gelatine, and in balsam; its markings were much more clearly seen when the mounting medium was of a refracting power a little less than the starch.

* "Body" is the power of hiding that which is beneath them when laid on as pigments.

The translucency of white material having been acknowledged, the question, "Is anything opaque?" was next considered; and it was shown that no definite line could be drawn between transparent and opaque bodies; for, while nothing is found to transmit light without some loss, nothing is found absolutely impervious to light when reduced to a thin film. In most cases where much light is obstructed, some rays pass more freely than others, as indicated in the following table:—

LIGHT TRANSMITTED.

Through gold-leaf,	is green.
" " tempered	" brown.
" gold chemical films,*	" grey violet.
" " " powders,*	" red, purple, or blue.
" silver-leaf,	" grey violet.
" " chemical films,	" purple or brown.
" copper,	" green.
" antimony,	" grey.
" arsenic,	" brown.
" platina,*	" grey.
" palladium,*	" grey.
" rhodium,*	" brown or blue.
" charcoal,	" grey.
" iodine,	" red brown.

Taking the word "opaque" in its ordinary acceptation, the question, "Are all opaque bodies black when in a fine state of division?" was next discussed; and it was shown by diagrams how the breaking up of a smooth surface diminished the amount of light availably reflected from it. It was also shown that comminution produces subjacent surfaces which reflect some of the light transmitted by the first surface, and that with a certain degree of fineness the more transparent the material the more light will be reflected from the subjacent surfaces; and it was concluded that bodies become lighter colored by powdering if their power of absorbing light is so small that the reflection from the subjacent surfaces more than compensates for the loss of reflection from the breaking up to the primary surface; and they become darker if the absorbing power is so great that the reflection from the subjacent surfaces does not compensate for the loss of reflection caused by the breaking up of the primary surface.

The doctrines of correlation and conservation were then briefly treated, and it was argued that light falling upon black bodies was neither annihilated nor absorbed, but converted into some invisible form or force; the power of the black body being, in some degree, the converse of that possessed by fluorescent and phosphorescent bodies, by which they convert invisible into luminous rays.

The fact, that reflection is not purely a superficial phenomenon, was then pointed out, as indicated by those parts of a soap-bubble which are too thin to reflect light being still possessed of two surfaces; and the questions were raised—If matter at some depth, however small, beneath the surface, continues to reflect light, at what depth

* These are quoted from Faraday in *Phil. Mag.*; the others were exhibited to the meeting.

does it cease to do so? Does it ever cease to do so? Or does the transmitted ray, as it speeds on its journey, always send back a beam in the opposite direction?

Different kinds of reflecting surfaces have different appearances; this is probably due, in some measure, to the effect produced upon the light by its passage into and out of that thickness of matter which is concerned in ordinary reflection.

Of homogeneous matter, we have opaque and transparent; the former giving metallic lustre, the latter vitreous. As a general rule, if not a universal, we find the more nearly a substance approaches the metals in opacity, the more it resembles them in the nature of its lustre. Thus sulphurets are in many cases very nearly opaque, and very like metals in the nature of their lustre. Carbon in its opaque form is a brillant steel grey; while its transparent form has the vitreous lustre.

A micaceous or pearly lustre is the result of the superposition of a number of films of transparent material; the reflection from the first surface being added to by the reflections from the subjacent surfaces.

When light falls upon glass and is reflected, it is commonly said that the glass reflected. The speaker drew attention to the important part played by the air or other medium in contact with the reflecting surface, and illustrated it by obtaining total reflection from the surface of a prism when air was in contact with it, and only feeble reflections when the air was replaced by water or oil of turpentine; even a film of silver deposited on the prism was shown to reflect less light than a film of air. By a simple contrivance it was then shown that white paper reflects more light than a looking-glass, and that the appearance of lustre depends upon the reflection of shadows as well as of lights.

Mr. Proctor concluded his subject with the following words:—

"Sir D. Brewster, and other writers on optics, give the length of a wave of white light, the number of undulations in an inch, and the number in a second, calculating it as the *mean* of the number of undulations in the colored rays; apparently forgetting that it is not the mean but the sum of the colors which forms white light—the mean being, according to Brewster's own table, yellow, with a tinge of green. Various writers have, probably, copied from the same source without investing thought upon the subject; one indication of which is, that several say so many millions of millions, whereas it would be more natural to say so many billions. I will just give you Brewster's figures, and then pass on:—

	Length in parts of an inch.	No. in an inch.	No. in a second. Millions of Millions.
White, . .	0·000225	44444	541
Yellow, . . .	0·000227	44000	535
Yellow Green .	0·000219	45600	555

"You observe the numbers given for white light are the same that would belong to a color between yellow and yellow-green. White light, we may conclude, is not a definite undulation, nor a definite mixture of undulations, but a variety of mixtures of undulations, in any of which mixtures the average length of an undulation is that given by Brewster and others, but the number in an inch or a second is incalculable and indefinite. The lengths of the undulations in a pure unmixed color is probably definite, and we have no reason to object to the measure and number usually adopted; we shall, therefore, accept them for further argument.

"The length of an undulation of violet light is seventeen-millionths of an inch; the red undulation twenty-six millionths, or about one-half longer; undulations, longer or shorter than these, not being visible. The colors observed in soap bubbles and other thin films are produced by interference of the luminous waves. The color produced depends upon the relation between the thickness of the film and the length of a wave of light. A film of air, four millionths of an inch thick, produces the same color as a film of water three-millionths, or of glass two-and-a-half millionths of an inch thick. Therefore, we conclude that the length of the light wave varies with the medium. An undulation in air, measuring four, will measure only two-and-a-half when it enters glass, and will again elongate to its former measure on its exit. From these premises we may deduce various interesting conclusions. Faraday found that gold films were iridescent when they were only one-tenth the thickness at which air ceases to be iridescent. May we, then, conclude that light, while passing through gold, consists of undulations only one-tenth the length of those in air? Newton found that the thickness of films of a given color was inversely proportionate to their indices of refraction. May we, then, conclude that gold has a refracting power in like proportion? If we say that luminous undulations, which in air measure twenty-two millionths of an inch, look yellow when they enter the eye, and in that organ measure one-third less, in consequence of its refracting power, then we come to the singular conclusion that the blue sky is yellow, sunshine is red, and the rosy tints of evening are not luminous at all until they enter the eye. If the color depends upon the length of the light wave, and the length of the wave depends upon the refracting power of the medium through which it is passing, every beam of light changes color; red it may be on its passing through the region of the stars, yellow or green it may be when it enters the air, blue or violet when it enters water, non-luminous as it passes through glass. But if light, which we perceive as violet while it exists in the aqueous humor of the eye, was red originally, what color must that light be which we perceive as red? Its undulations in air must be too long to be luminous. This introduces us to the solemn thought, that all this vast universe is dark! Light exists only in the eye. It is only a sensation—a perception of that which in nature exists as a force capable of producing a sensation. We would feel grieved at the thought of light and sound having no tangible existence independent of ourselves, were it not for the glori-

ous hope that all nature is full of forces equally grand—forces which we have not the power of perceiving, but which, with a higher development of our organism, may be sweet as music and genial as sunshine."

Austrian Gun Cotton.

From the London Chemical News, No. 175.

Take cotton yarn and twist it into strands of suitable size to answer the same purpose as grains in gunpowder. (The size of these strands can only be ascertained by experiments.) It is then steeped for a few minutes in nitric acid contained in a stoneware vessel, squeezed, and thoroughly washed by water, which is permitted to fall upon it from a pipe set at a height of several feet. After this it is squeezed, and dried in a room heated to 130° Fahr., when it is ready to be treated with a mixture of nitric acid of 1·52 specific gravity, and sulphuric acid of 1·14 specific gravity. These acids, in equal quantities, are mixed together in a glass or stoneware vessel, and allowed to stand for twenty-four hours; then the prepared yarn is immersed in it for forty-eight hours, with occasional stirring; the vessels being covered; then it is squeezed, washed for several hours in running water, and dried again. After this it is soaked for a short period in dilute silicate of potash, squeezed, washed again, dried, and is fit for use. This gun cotton is manufactured by M. Reny, of Vienna. It emits but little smoke, and is not subject, like common gun cotton, to explode by percussion.

Discharge of Artesian Wells, observed at Different Heights. By M. Michal.

From the Gas Light Journal, No. 269.

M. Darcy, Inspector-General of the Department of Roads and Bridges, has investigated the general laws which regulate artesian wells, in his interesting work upon the public fountains of Dijon. The formulæ at which this eminent engineer has arrived are established on two distinct hypotheses, comprising, first, the artesian springs due to meeting with a subterranean current; and, secondly, the springs fed by sandy water-bearing strata, in which the water moves with an insensible velocity. In the latter case, which is the most general, it is possible to deduce from the formula applicable to it, by neglecting some terms which may be considered of no value, the law, that the difference between the heights at which the water flows above the soil is sensibly proportional to the difference of the volumes observed at those heights. It follows from this, that if the result of two observations of the delivery of an artesian well are known, it is possible to form an equation of the first degree, which should yield, in an approximate manner, the produce of the same well at heights above the soil different from those at which the observations, which served to form the equation of the first degree, were made.

This law is confirmed by the experiments, made with the greatest

care at the well of Grenelle, about the end of February, 1844, by M. Mary, Inspector-General, and M. Lefort, Engineer-in-Chief of Roads and Bridges. But a formula of interpolation is thus obtained, in which the diameter of the ascensional tube, and its height, measured from the artesian spring to the point of overflow of the waters, are entirely omitted. It must, however, be understood that it is important to take into account the influence these elements may exercise upon the yield of a well, and to establish, consequently, a formula which should be a function of the height of the ascensional tube and its diameter. I propose at present to investigate these conditions.

When, in an artesian well, the movement has become uniform and permanent, there is an equilibrium between the effort resisting the motion of the water, and the unknown effort producing the motion, which acts upon the lower part of the tube to produce the ascensional movement in the water of the stratum which yields the artesian spring. An observation of the quantity discharged, under these circumstances, would indicate the motive power, as a function of the *work resisting*, corresponding with the quantity so discharged. It is possible, therefore, generally to obtain another discharge, by rendering the resisting work which results from it equal to the working power ascertained by the first method of observation. This will remain a constant quantity, provided the new combinations do not introduce any disturbing elements in the *régime* of the artesian stratum.

We should thus obtain the formula—

(A) $$q_u = \frac{2\, q_o\, H_o - g\, h_u\, \omega}{2\,(H_o + H_u)}$$

in which the resistance resulting from the friction of the water in the ascensional tube, and that resulting from the loss of the *vis viva* at the lower end and at the upper end of the tube, are not taken into account. We should have, nevertheless, q_o equal to the discharge observed at the height, H_o, above the artesian stratum, g, the double of the space traversed during the first moment of its fall; ω, the section of the lower part of the tube; q_u, the delivery calculated at a height, h_u, above the point of discharge of the volume, q_o. If we suppose the section of the tube to remain constant throughout its length, we should deduct from the formula (A)—

(B) $$q_u = \frac{2\, v_o\, o\, H_o - g\, h_u\, o}{2\,(H_o + h_u)}$$

in which o represents the constant section of the tube, and v_o the rate of discharge per second of the discharge observed. The formula (B) shows that, by collecting in the same boring the waters resulting from different diameters, the product, all other things being equal, augments with the diameter of the bore; but that this condition may be fulfilled, it is necessary that the water-bearing stratum should furnish the water discharged at the orifice, without encountering any variations. But experience has proved that the power of artesian springs has limits which cannot be surpassed. It will be easy, then, to believe that, in a

boring which reaches a stratum yielding an artesian supply, there is a diameter to be adopted for the ascensional tube, which will yield the maximum of the delivery that can be obtained at a given height above the water-bearing stratum.

We will now proceed to apply our formula, and that of M. Darcy, to calculate the rate of discharge of the wells at Grenelle and Passy.

Well at Grenelle.—We will take, to determine the constants of the formula (A), the observation No. 1; and, to form the equation of the right line of Darcy, the observations Nos. 1 and 10 of the subjoined table, which reproduces the values of the discharges observed at different heights by MM. Mary and Lefort, and that calculated in the two hypotheses indicated:—

Number of Observations.	Height of the Points of Discharge observed above		Discharges		
			Observed by MM. Mary and Lefort.	Calculated by Formula.	
	The Sea.	The Soil.		(A.)	Darcy.
			m.	m.	m.
1	37·90	0·00	0·02000	0·02000	0·02000
2	40·95	3·05	0·01867	0·01925	0·01930
3	43·00	6·10	0·01822	0·01852	0·01861
4	50·00	12·10	0·01700	0·01711	0·01724
5	52·40	14·50	0·01638	0·01655	0·01669
6	53·55	15·65	0·01588	0·01628	0·01643
7	56·30	18·40	0·01524	0·01567	0·01580
8	62·95	22·05	0·01426	0·01425	0·01428
9	66·40	28·50	0·01342	0·01339	0·01349
10	71·00	33·10	0·01244	0·01236	0·01244

It will be seen that the discharges, calculated by either formula, differ but little from those observed; nevertheless, they are rather less exactly reproduced by the formula of Darcy than by our own, which is completely determined when a single discharge is known. So that it would have been possible to have calculated, by means of the formula (A), controlled by a single observation upon the surface of the ground, in a manner sufficiently near, all those observed above the first point recorded by MM. Mary and Lefort. It is necessary to observe that these results are obtained in the hypothesis that the artesian spring should communicate with the ascensional tube by the lower orifice; but it often happens that this communication takes place by means of an orifice greater or less than that of the above, whether it be increased by the formation of an excavation at the lower extremity of the ascensional tube, or diminished by the orifice being obstructed by fragments of rock, or by any other cause. In these cases it will be necessary to employ a second observation to determine the orifice of communication of the artesian spring with the ascensional tube.

Well at Passy.—The communication of the artesian spring with the ascensional tube takes place not only by the lower orifice, whose surface is equal to $0^{m}\cdot3850$, but also by the auxiliary apertures made in the lower part of the tube. By taking, for the sake of determining the contents of the formula (A), the observations Nos. 1 and 5 of the table hereinafter given—which contain those made in the end of 1861 and the beginning of 1862—we shall find $\omega = 0^{mq}\cdot5114$. By forming equally the equation of the right line by the observations Nos. 1 and 5, we arrive at the following table, analogous to the preceding one:—

Number of Observations.	Height of the Points of Discharge observed above		Discharges		
	The Sea.	The Soil.	Observed.	Calculated. (A.)	Calculated. Darcy.
			m.	m.	m.
1	52·30	0·00	0·1779	0·1779	0·1779
2	59 32	6·02	0 1441	0·1504	0·1512
3	65·25	11·95	0 1197	0·1237	0·1248
4	73·15	19·85	0·0846	0·0889	0·0892
5	77·15	23·85	0·0718	0 0718	0·0718

It will be seen that in this case, also, the values deduced from the application of either formula differ very little from those derived from actual observation. Extract by the Author, from the "Comptes Rendus de l'Acad. Sciences."

On Aluminium Bronze as a Material for the Construction of Astronomical and other Philosophical Instruments. By Lieut.-Colonel A. Strange, F.R.A.S.

The author, after referring to the astronomical and geodesical instruments about to be constructed, under his superintendence, by order of the government, for the use of the great Trigonometrical Survey of India, and after noticing that one of the points which has given him most anxiety had been the selection of the proper material or materials of which to construct these instruments, and that his present remarks were confined to the great Theodolite with a horizontal circle 3 feet in diameter, and after detailing the requirements of such an instrument, proceeds as follows:

Such then was the problem presented for solution: to construct an instrument with extended powers, and cast as much as possible in masses, the transportation of which over the most difficult ground should not be beyond the power of human labor.

When on the point of compromising the difficulty by separating, so as to form distinct packages, parts hitherto regarded as inseparable, my attention was attracted by the various articles made of *aluminium bronze*, sent to the International Exhibition by Messrs. Bell Brothers

of Newcastle, and M. Morin of Paris. The inquiries I made in various quarters satisfied me that this metal possessed most valuable qualities, but I failed in my endeavors to obtain reliable numerical data for comparing it with other metals. I therefore instituted experiments on it, the results of which I beg now to communicate to the Society.

The alloy called aluminium bronze was first, I believe, made by Dr. Percy five or six years ago, and is composed of aluminium and copper in various proportions, 10 per cent. of aluminium, however, giving the best material for mechanical purposes.

The qualities of most importance in instrument making are, 1. Tensile strength; 2. Resistance to compression; 3. Malleability; 4. Transverse strength or rigidity; 5. Expansive ratio; 6. Founding qualities; 7. Behavior under files, cutting tools, &c.; 8. Resistance to atmospheric influences; 9. Fitness to receive graduation; 10. Elasticity; 11. Fitness for being made into tubes; 12. Specific gravity.

Of these, tensile strength, resistance to compression, and malleability were most obligingly tested for me by Mr. Anderson at the Royal Gun Factory, Woolwich; and the other qualities by Messrs. Simms, by whom the great Theodolite is now being constructed. I will take the above enumerated properties in their order, premising that to have obtained results of an absolute and final character would have involved more time than I can spare, and that therefore those which follow, though sufficiently reliable for almost any practical purpose, are open to the correction of more extensive experiments.

1. *Tensile Strength.*—This was tried some years ago by Mr. Anderson with the following results:

Aluminium bronze,	.	95,747 } Breaking strain.
Gun metal,	. .	32,000 } lbs. per sq. inch.

Mr. Anderson was good enough to try it again for me in September last, and states in his report:—"The average tenacity of this metal proved to be 22 tons 12 cwt. (50,624 lbs.) breaking weight per square inch in the two specimens tested; elongations did not take place until 4300 lbs. in the one case and 3600 lbs. in the other had been applied, when a permanent elongation was noticed of ·009 of an inch in the first specimen, and ·034 of an inch in the last." Mr. Anderson adds that the specimens were not quite sound.

In the above cited report Mr. Anderson gives a higher tensile strength to gun metal than before, namely, 17 tons (38,080 lbs.) for the average of the "*best specimens*" tested at the gun factories.

Combining the results, we have the average breaking tensile strength of the two metals as follows:

$$\text{Aluminium bronze, } \frac{95747 + 50624}{2} = 73{,}185 \text{ lbs. per sq. inch.}$$

$$\text{Gun metal, } \frac{32000 + 38080}{2} = 35{,}040 \text{ " "}$$

The ratio being 1 to 0·48, or rather more than 2 to 1 in favor of aluminium bronze.

For the purpose of comparing the tenacity of the new alloy with steel, we have data given by Mr. Anderson in a lecture on Materials for Rifled Cannon, in which he states that cast steel varies in tensile strength from 114,000 to 67,000 lbs. per square inch; but he objects to the higher qualities as liable to brittleness, and prefers, where great strains are in question, an average quality of cast steel breaking at 80,000 lbs.; and he adds, that specimens from a gun made of Krupp's famous cast steel, characterized by "softness" (which Mr. Anderson considers favorable to tenacity) and "perfect soundness," gave 72,000 lbs. per square inch, which we see is 1185 lbs. less than the average strength of aluminium bronze above given.

2. *Resistance to Compression.*—Mr. Anderson reports on this as follows:

"The ultimate amount of compression applied was 59 tons 2 cwt. 1 qr. 4 lbs. (132,416 lbs.), under which the specimen* became too much distorted to permit of more weight being applied with any true result. Compression was not perceptible until 9 tons 2 cwt. per square inch (20,384 lbs.) was applied, when the specimen suddenly gave to the extent of ·006 of an inch, and on the weight being removed an elasticity of ·001 was observed, which gives the first permanent compression as ·005 of an inch."

The compressive strength of cast iron varies a good deal. That of "Carron Iron, No. 3," the highest given in Ure's Dictionary of the Arts, is 115,542 lbs. per square inch; but it is difficult to compare in this respect two metals whose behavior under compression is so different, cast iron yielding suddenly and almost totally, and the new alloy more gradually and partially. Astronomical instruments, however, are more dependent on the rigidity or resistance to a transverse force than on any other quality.

3. *Malleability.*—Mr. Anderson states on this head:—

"The qualities of this metal for forging purposes would appear to be excellent; with the exception of the part heated to a red heat in the shade, all show that it is a good workable material under the hammer almost up to melting point."

I may add that there were specimens in the Exhibition, showing that the alloy could be drawn out under the hammer almost to a needle point.

I come now to the experiments tried by Messrs. Simms.

4. *Transverse Strength.*—As the absolute determination of the force necessary to break or permanently bend a bar of metal was beyond our appliances, I begged Messrs. Simms to be satisfied with a comparative value of the rigidity of the new alloy; that is, to ascertain the relative resistances of gun metal, brass, and aluminium bronze, to a force insufficient to produce permanent flexure. This they succeeded in doing, and report as follows:—

The same weight applied to three bars altered the index of our instrument thus:

* "The specimen subjected to this enormous pressure, distorted though it is, does not exhibit the trace of a fissure. The cohesion of its particles is inviolate."

Brass, ...	2·22 divisions.
Gun metal, . . .	0·15 "
Aluminium bronze, . .	0·05 "

Hence, aluminium bronze would appear to be 3 times more rigid than gun metal, and upwards of 44 times more rigid than brass.

5. *Expansive Ratio.*—This determination was also a comparative one. Messrs. Simms found that "aluminium bronze is less affected by change of temperature than either gun metal or brass (a little less than gun metal, and much less than brass)."

6. *Founding Qualitites.*—Regarding this there is ample experience. The alloy produces admirable castings of any size.

7. *Behavior under Files, Cutting Tools, &c.*—In this respect, also, it leaves nothing to be desired. It does not clog the file; and in the lathe and planing machine the tool removes long elastic shavings, leaving a fine, bright, smooth surface. Messrs. Simms state: "It can be worked with much less difficulty than steel, and we should think that screws made of it would (notwithstanding the original great cost of the metal) prove in the end less expensive than screws made of steel."

8. *Resistance to Atmospheric Influences.*—Messrs. Simms state, "it does not really tarnish." This, likewise, is entirely a relative question. Absolute inoxidizability, however desirable, is hardly to be expected. Suffice it, that the new alloy tarnishes much less readily than any metal usually employed for astronomical instruments, viz: gun metal, brass, silver, cast iron, or steel.

9. *Fitness to receive Graduation.*—Messrs. Simms state, "Aluminium bronze takes a fine division, and it will not be necessary to inlay another metal, as is usually done, to receive the graduation." This opinion is fully justified by the specimen of graduation executed by Messrs. Simms, the lines of which are remarkably pure and equable, characteristics never presented in the same degree, they inform me, by lines cut on any other *cast* metal. May not this superiority indicate that the alloy in question is peculiarly homogeneous? The lines are very distinct under the microscope, notwithstanding the yellow color of the metal.

10. *Elasticity.*—I possess no direct experiments bearing on this point. But that the alloy has considerable elasticity is unquestionable. I may here state that an eminent Parisian instrument-maker informed me, that of all the wires tried for the suspension of Foucault's Pendulum for illustrating the rotation of the earth, none, not even those of steel, were so durable under that severe ordeal as wires made of aluminium bronze. It would appear, therefore, to be the most proper material for the suspension springs of clock pendulums.

11. *Fitness for being made into Tubes.*—It admits of every process necessary for this purpose. It can be soldered with either silver or brass solder; it can be rolled into sheet metal; and it can be hammered and drawn. Hitherto telescope tubes, the cones of transit axes, the

pillars of altazimuths, &c., have been made almost exclusively of yellow brass, a metal very deficient in rigidity. Gun metal does not admit of being rolled, and has therefore never been used for the tubular parts of instruments, for which the new alloy seems pre-eminently suitable.

12. *Specific Gravity.*—The specific gravities of alloys of aluminium and copper, as determined by Messrs. Bell, are

3	per cent. of	aluminium,	8·691
4	"	"	8·621
5	"	"	8·369
10	"	"	7·689

The last named, which is the best for the purposes now under notice, is very nearly the same as that of wrought iron, and less than that of either brass or gun metal.

It appears from these experiments, and from the concurrent testimony of those who have given it a fair trial, that the 10 per cent. aluminium bronze is far superior, not in one or some, but in every respect, to any metal hitherto used for the construction of philosophical apparatus, and that for such purposes it may be employed in the dimensions that would be proper in the case of cast steel. All parts which otherwise would be made of steel may, with perfect safety and even with advantage, be made of the new alloy, particularly such parts as bolts, and fixing tangent and micrometer screws. Its hardness and comparative inoxidizability point it out as peculiarly adapted for pivots, axes, and bearings. If employed for receiving the graduation of circles, the necessity for inlaying another metal will be obviated, by which two advantages will be gained; the hammering which forms part of the operation of inlaying, and which, more or less, must cause unequal density and tension in the circle subjected to such treatment, will be dispensed with; and the effect of inequality of expansion in the circle and the inlaid strip will no longer be a cause of apprehension. With respect to the due visibility of divisions cut on this metal, opinions will perhaps differ. I can only say that I should be well content to observe with them.

The use of this alloy for the construction of the new great Theodolite is, in the opinion of Messrs. Simms, and in my own, fully justified by what we now know of it; and the effect of using it will be to keep the weight of the instrument within reasonable limits, notwithstanding its possession of means and appliances not hitherto bestowed on such instruments.

Two points remain; the making of the alloy, and its cost.

The metal aluminium is at present extracted in England by one firm only, Messrs. Bell Brothers, Newcastle, under a license from M. Deville, the French discoverer of the process. I have met with instances of failure in making the alloy with copper. Two main points only, however, seem to require particular attention. First, extremely pure copper must be used. The best is copper deposited by electricity, but that kind is very expensive; the next best is copper from Lake

Superior, which makes an alloy of excellent quality. The ordinary coppers of commerce generally fail, owing, it is said, chiefly to the presence of iron, which appears to be specially prejudicial. The second precaution is to re-melt the alloy two or three times. The first melting of 10 aluminium and 90 copper produces an alloy of excessive brittleness. Each successive melting, up to a certain point determined by the working and particularly by the forging properties of the metal, improves its tenacity and strength. It is probable that after several meltings there will remain in combination with the copper a somewhat smaller proportion of aluminium than 10 per cent.

The present price of the English made 10 per cent. aluminium bronze is 6s. 6d. per lb., but there is reason to believe that, as the process of extracting the aluminium becomes more largely practised, and the demand for the metal increases, the price will fall. The above price is four or five times that of gun metal. A much smaller quantity, however, of the new alloy than of gun metal will give the same strength; and when it is considered how small a ratio the cost of the material bears to the cost of workmanship in refined apparatus, it will be found that even at the present price of the new alloy its cost is not prohibitory, whilst the advantages attending its use promise to outweigh the increased expenditure.

In the foregoing paper, which I am aware is very imperfect and incomplete, I have sought no more than to contribute such an instalment of practical information regarding this remarkable material as may be of service to those who, like myself, contemplate making use of it, of whom I trust there will be many, for by its use we shall, I venture to think, confer on such structures at once greater strength and less weight, and so diminish tension, flexure, and distortion, to an extent calculated sensibly to improve the higher order of instruments of physical research.

Proceedings of the Royal Astronomical Society, Nov. 14, 1862.

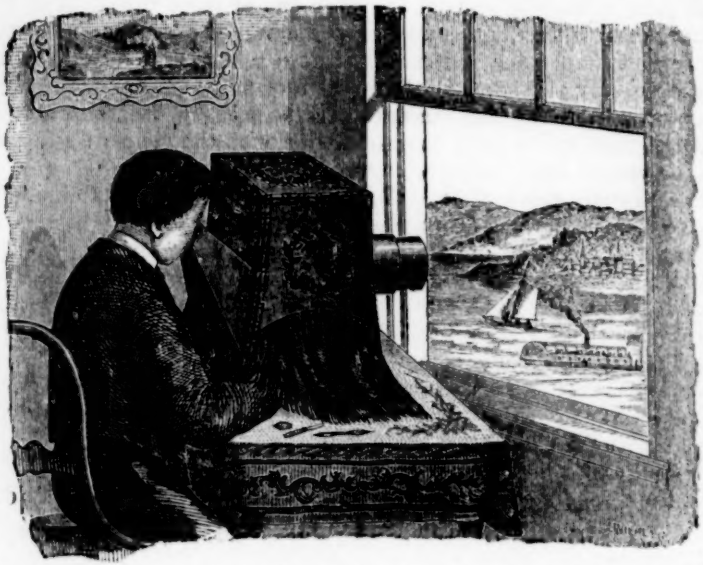
For the Journal of the Franklin Institute.

G. F. Kolb's Improved Camera Obscura.

The annexed cut represents a neat and compact camera for the use of artists and those who are interested in drawing either as a profession or as an amusement. The instrument consists of a case blackened on the inside, the most convenient form being that represented in the cut.

To the front side of the case is secured a tube in which slides another tube containing a lens, and in the opposite side of the case is an oblong opening surrounded by a similarly shaped tube; the latter being placed at such an angle that on looking through it the entire or nearly the entire bottom of the box is exposed to view. Opposite to the lens tube, in the interior of the box, is a reflector placed at such an angle as to cause the rays of light which pass through the lens to be thrown on to a second reflector which directs them on to a sheet of paper deposited upon the bottom of the case. On the right hand side

of the latter is an opening covered by a curtain, so that the hand may be introduced into the box and trace with a pencil the forms of the objects thrown upon the paper.



These instruments are well calculated to foster a taste for drawing and are useful in attaining the principle of perspective.

They are made in a great variety of style by Mr. G. F. Kolb, of this city.

Steel for Fire-Arms.

From the London Artizan, May, 1863.

Capt. Caron has been for some time addressing papers to the Academy of Sciences about his experiments on steel, effected at the Depôt des Poudres et Saltpétres, for the purpose of applying that metal to ordnance and fire-arms in general. More than twelve months ago, samples of a peculiar soft steel were brought to the artillery factories, and the remarkable qualities of this metal induced Colonel Trielle de Beaulieu, the director, to apply it to the manufacture of tubes intended to protect the copper of the points of sight of heavy ordnance. This steel has the property of drawing cold, in tubes of any dimensions, and after drawing—above all, if the metal be tempered—the grain, perfectly homogeneous, is fine and watered, the steel has become strengthened (*nerveux*), and offers an extraordinary amount of resistance. Since then, gun barrels, manufactured from the same material, have been presented to the factory for the models of arms, and Captain Maldin, director of this establishment, struck by the beauty of this metal, thought it his duty to try the barrels, in order to establish their quality. The following are the very curious results at which this

officer has arrived:—A gun barrel of the ordinary dimensions of that of a sporting gun, after having been trued, was tried first with 30 grammes (1 oz.) of powder, and one ball of 37 grammes (1¼ oz.) This charge, producing no deterioration, was followed by trials with a ball of the same size, and increasing the charge by 10 grammes at a time up to 60 grammes (2 oz.) The 60 grammes were then replaced by 40 grammes of extra fine Esquerdes powder (the most destructive powder known). Not being able to burst the barrel, the experiments were continued with gunpowder, and after some trials, a charge of 150 grammes (5 oz.) was arrived at without inducing a rupture. A last experiment was then tried, in which 150 grammes (5 oz.) of powder and five balls were employed, the latter weighing together 135 grammes (say 4½ oz.) well rammed home. The only injury seen was a swelling in the barrel at the spot where each of the balls was placed, but the barrel was not burst, not even cracked. If it be considered that the charge of powder was already 23 ins. long, and that a more considerable quantity would not have had time to burn entirely, it may be fearlessly concluded from these experiments that the metal employed in the manufacture of these barrels is capable of giving arms which cannot be burst by the effort of any charge of powder whatever.

Strength of the Fibres of Orleans Cotton.

From the London Practical Mechanic's Journal, May, 1863.

Mr. Charles O'Neill exhibited a mounted fibre of Orleans cotton, torn by a gradually increasing weight suspended to its extremity. It had sustained a weight (gradually increased) of 162 grains for many minutes. Mr. O'Neill stated that there were 143 such fibres in ·01 grain of cotton, each fibre therefore weighing less than the ten-thousandth part of a grain. The strongest fibres were capable of supporting more than two million times their own weight. He is engaged in making experiments upon the tensile strengths of various fibres by a special apparatus, but they are not yet completed.

Proc. Manchester Lit. and Phil. Soc., March 16, 1863.

Dimensions of the Earth's Coal Fields.

From the London Artizan, May, 1863.

Professor Rogers states, we have it on the authority of competent surveyors, that the great coal-field of South Wales, the largest and deepest in Europe, covers a surface of not less than 1000 square miles, and has a maximum thickness of from 7000 to 12,000 feet in its coal measures. In this prodigious "book of time," there are, it has been commuted, not less than 50 beds of coal, from 6 inches to 6 feet in diameter, and 25 of these are said to be each at least 2 feet thick. The smaller Forest of Dean coal basin contains, according to the "Memoirs of the Geological Survey," 31 coal beds in a thickness of coal measures of 2400 feet. From the same source (the survey) we learn that the North Staffordshire coal measures have an aggregate depth of about 5000 feet; while those of the Newcastle district are

believed to be at least 2000 feet thick, and to embrace a total thickness of coal equivalent to 60 feet. In the deepest portions of the extensive coal basin of Scotland, the upper productive coal measures of Mid-Lothian have been found by the survey to possess a thickness of not less than 1800 feet. The number of the seams of coal wrought in the Lanarkshire field is in all 18. Turning to other countries, the depths or thicknesses of the coal measures, and the numbers of coal beds, will be found to be on an equally grand scale. Looking first to the western side of the Atlantic, North America displays, commensurately with the breadth of her physical features generally, several enormous coal regions, three at least of which are the largest known upon the globe. One of these, the Appalachian basin, has a length of 875 and a maximum breadth of 180 miles, with an area in square miles of 55,500. Where deepest its coal beds have an aggregate thickness of 40 feet. A second, the coal-field of Illinois, Indiana, and Kentucky, has length, 370, maximum breadth 200, and area 51,100 miles. This basin has 15 or 16 good coal seams, with a maximum thickness of 50 feet, and the third and largest, but least opened, shows length 550, breadth 200, and superficial area 73,913 miles. In the anthracite basin of Pennsylvania, the thickness of coal measure, amounts to 3000 feet, while that of the workable coal is not less than 120 feet. The aggregate area of the five chief coal fields of the American continent, amount by careful estimates based upon the latest surveys and the best geological maps, to rather more than 200,000 square miles; a surface greater by about 20 times than the sum of all the coal-fields of Europe, or, indeed, of the whole Eastern world. The British carboniferous basins may be estimated to embrace some 5400 square miles of coal; the French a little less than 1000; and the Belgian about 510. Rhenish Prussia has 960; Westphalia 380; the Bohemian field some 400; that of Saxony only 30; that of Spain probably 200; and that of all Russia scarcely 100 square miles. Comparing the coal areas with the total surfaces of the respective coal producing countries, the United States has one square mile of coal to each 15 of land; Great Britain one to every 22½; Belgium a like proportion; and France but one of coal to every 200 of country. Adopting for the commuted total area of the coal-fields of the world 220,000 square miles, and accepting 20 feet (a low estimate) for the average thickness of the available coal, the entire mass of the fuel under the soil for the future wants of man amounts by calculation to a cubic lump of nearly ten miles lineal dimensions, or to a square plateau of coals of 100 miles wide in its base, and something more than 500 ft. in height. The British lump of coal is a cube of a little more than three miles in diameter. In 1854 Great Britian extracted from her mines more than 64,000,000 tons. In 1861 the product was about 80,000,000 tons, equal to a cubic block of 430 yards in height. For the present year the probable product may be safely estimated at not less than the enormous quantity of 100,000,000 of tons. In the preliminary report lately printed on the census of the United States for 1860, it is shown that the coal product of the state of Pennsylvania amounted in that year to about 11,500,000 tons, while that of all the coal yielding

states together exceeded 15,000,000 tons. In the year 1850 Belgium took from her mines nearly 6,000,000 tons; France some 4,500,000 tons, and Prussia nearly 4,000,000 tons. It has been calculated that one-fifth at least of the present vast product in coal of the civilized world, which fifth part we may roughly estimate at nearly 30,000,000 tons annually, is applied in the smelting and manufacture of iron alone, and it is probable that more than one-tenth of the whole of the fuel lifted, or some 15,000,000 tons, is coverted directly into mechanical power, through the generation of steam for the propulsion of machinery.

For the Journal of the Franklin Institute.

Evans, Jenkins, and Durborow's Governors for Steam Engines.

Through mistake, this invention was described in the last number of the *Journal* as belonging to Messrs. Jenkins and Jumelle, the owners of the invention in Europe. The right to the invention in this country is vested in H. W. Evans, C. C. Jenkins, and W. H. Durborow, and should have been so stated. H.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, May 21, 1863.

John C. Cresson, President, in the Chair.

John Agnew, Vice President,
John F. Frazer, Treasurer,
Isaac B. Garrigues, Recording Secretary,
} Present.

The minutes of the last meeting were read and approved.

Letters were read from Thomas Oldham, Esq., Superintendent of the Geological Survey of India, and the Geological Museum, Calcutta, India, and from the Smithsonian Institution, Washington, City, D. C.

Donations to the Library were received from the Royal Society, the Royal Institution, the Royal Geographical Society, the Royal Astronomical Society, the Society of Arts, the Chemical Society, and the Commissioners of Patents, London; the Royal Irish Academy, Dublin, Ireland; the Geological Survey of India and the Geological Museum, Calcutta, India; the Société d'Encouragement pour l'Industrie Nationale, and l'Ecole des Mines, Paris, France; the Numismatic Society, and Major L. A. Huguet Latour, Montreal, Canada; Samuel McElroy, Esq., Brooklyn, New York; T. C. Zulich, Esq., Harrisburgh, Penna.; Isaac S. Cassin, Esq., the Select Council of the City of Philadelphia, and Professors John C. Cresson and T. S. E. Lowe, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of April.

The Board of Managers and Standing Committees reported their minutes.

The Standing Committee on Meetings reported that they have organized for the present year by electing Henry Howson, Esq., Chair-

man, and appointing the third Thursday evening in each month for their stated meetings.

A candidate for membership in the Institute (1) was proposed, and the candidates (3) proposed at the last meeting were duly elected.

Mr. Joseph Clay exhibited his Patent Air Spring Trusses. The pads consist of india rubber hollow semi-spheres, distended with air and covered with cotton fabric; they are mounted upon a piece of leather, having the usual straps and buckles. The ball has sufficient elasticity to perform its office, and at the same time yield to an unusual pressure if brought upon it by accident; thus preventing bruising of the part in contact.

The Committee on Meetings presented the following articles:—A piece of the Armor Plate of the Whitney Battery, *Keokuk*, punched through by a ball during the late attack upon Fort Sumter. It seems to have been struck by a nine-inch round shot, a portion of which was shown at the same time. The iron is of good quality, showing fibres at line of rupture. The blow was not perpendicular, judging from the appearance of the piece, which resembles the bowl of a table spoon, with the pointed part rounded off. The back or converse part where first struck, shows the stretching of the iron before rupture took place. The piece is evidently a part of the inner plate of turret, which is composed thus: first an inner plate of $\frac{1}{2}$-inch thickness, upon which are placed edgewise, bars of iron 1 inch thick by 4 inches wide, and $1\frac{1}{4}$ inches apart; the interstices being filled with yellow pine wood; upon these are placed three plates, each $\frac{5}{8}$ths thick. The whole is fastened with bolts of $1\frac{1}{8}$ diameter, passing between the bars, and riveted into countersunk holes. This battery was not intended to resist the action of heavy ordnance at short ranges, but was designed for shoal river service, where the guns are generally of comparatively small calibre. Hence, the armor was placed as described, in order to obtain the greatest strength with least weight of material, so as not to exceed a draft of 8 feet when fully equipped. There is no doubt she was a very suitable vessel for such service, but entirely unfitted for the part she sustained against Fort Sumter, being nearer to its guns than any of the Monitor vessels, whose turrets have about twice the amount of material in them.

Some specimens of Marine Parasites taken from the bottom of the monitor *Passaic*. They are from 2 to 3 inches in length, tubular and semi-transparent. The attachment of these weeds to iron vessels, cannot be prevented by any known means, the patent composition paints being useless.

Mr. J. C. Garrigues exhibited his Patented Portable Book-case, which is made in sections easily taken apart. The upright ends are hinged in the centre, so that when folded, their length is equal to the breadth of the case; the shelves are connected to the upright ends by dovetails; to each shelf is attached the portion of the back of the case filling the space between the shelves. The case can be readily taken to pieces when necessary to remove it, as two screws only are used in each end

of the top of the case to secure it to the upright ends, which are held in position by the dove-tailed shelves. An additional advantage is, that when taken to pieces, by reversing two shelves, with their portions of the back, over each other, boxes can be formed for packing the books and for holding the ends and top piece of the case.

The Committee on Meetings exhibited a number of Glass Jars of several kinds, sealed by an improved elastic cap, the patent for which was recently issued to Messrs. Hartell & Letchworth, of this city. This improved cap consists of a rigid plate or disc, of metal or other material, with an annular flanch of gum elastic, secured to the edge of the disc. By applying this cap to the mouth of any suitable sized vessel, and turning down the rubber flanch, the latter grasps the vessel with a contractile force sufficient to hermetically seal the same, and preserve any substance within it from the action of the external air.

Another self-sealing device of Mr. Hartell's was shown, as applied to jars containing peaches, pears, &c., which had been enclosed therein for over three years. The fruit was stated to have been placed in the jar as picked from the tree, without any other preparation than to cover it with cold water. To all appearances the articles thus preserved were as solid as when first picked.

A sketch illustrating an invention of Messrs. Stileman & Ellis, for Smelting and Melting Iron, was shown. This consists in applying to a foundry cupola, or other furnace, a box, between the upper and rear side of which and the base of the cupola, is a pipe, which conducts the metal as soon as melted, from the cupola to the box, the blast from the cupola passing into the box and out of an opening at the side. The object of the invention is to get rid of the slag and scoria which float on the top of the metal in the box, and are blown out of the opening at the side of the same by the blast, the pure metal being drawn from the tap opening at the bottom of the box. It was stated that by this invention, from old retorts, otherwise worthless, over 75 per cent. of iron might be obtained.

It was promised on the part of the inventors that a full description of the operation of the furnace and the results obtained under different circumstances, should be laid before the Institute at their next monthly meeting.

Mr. U. B. Vidal, of this city, exhibited several Coal Oil Lamps of his invention, the wick tube of which, above the base of the burner, assumes a fan-shape, so that as the wick is raised the upper edge of the same is spread out to nearly double its former width. By this simple invention the oil carried up by the wick is distributed over so extended a surface that it is entirely consumed, and no portion can remain to clog the wick or run down the outside of the tube, to be evaporated and discharged into the air of the room, as is the case where a large supply of oil is constantly brought to a small burning surface. No chimney is needed with this lamp, which burns without smoke and with a clear flame.

A Comparison of some of the Meteorological Phenomena of APRIL, 1863, *with those of* APRIL, 1862, *and of the same month for* TWELVE *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

	April, 1863.	April, 1862.	April, 12 Years.
Thermometer—Highest—degree,	71·00°	82·00°	88·00°
" " date, . .	12th.	18th.	24th, 1861.
" Warmest day—Mean,	60·17	70·00	74·30
" " " date,	12th.	18th.	29th, 1856.
" Lowest, degree, .	30·00	28·00	20·00
" " date, .	4th.	9th.	7th, 1857.
" Coldest day—Mean,	33·33	33·20	27·70
" " " date,	4th.	9th.	2d, 1857.
" Mean daily oscillation,	14·90	17·87	16·73
" " " range,	5·41	5·89	6·32
" Means at 7 A. M., .	43·95	44·57	45·49
" " 2 P. M.,	54·35	55·23	57·25
" " 9 P. M., .	47·40	48·28	49·27
" " for the Month,	48·57	49 36	50·67
Barometer—Highest—Inches, .	30·185 in.	30·321 in.	30·518 in.
" " date, .	21st.	16th.	3d, 1854.
" Greatest mean daily press.,	30·177	30·300	30·458
" " date, .	21st.	15th.	3d, 1854.
" Lowest—Inches, .	29 260	29·422	28·884
" " date, .	2d.	22d.	21st, 1852.
" Least mean daily pressure,	29·387	29·439	28·959
" " date, .	2d.	22d.	21st, 1852.
" Mean daily range, .	0·164	0·146	0·172
" Means at 7 A. M., .	29·788	30·025	29·821
" " 2 P, M., .	29·752	29·979	29·779
" " 9 P. M., .	29 808	29·994	29·808
" " for the Month,	29·782	29·999	29·803
Force of Vapor—Greatest—Inches,	0·404 in.	0·555 in.	0·611 in.
" " " date, .	30th.	18th.	22d, 1853.
" " Least—Inches,	·072	·091	·066
" " " date, .	9th.	7th.	13th, 1852.
" " Means at 7 A. M.,	·207	·211	·231
" " " 2 P. M.,	·213	·219	·244
" " " 9 P. M.,	·232	·228	·249
" " " for the month,	·217	·219	·241
Relative Humidity—Greatest per cent.,	96· per ct.	94 per ct.	100· per ct.
" " " date, .	16th & 24th.	9th.	Often.
" " Least per cent,	15·0	18·0	13·0
" " " date, .	26th.	27th.	13th, 1852.
" " Means at 7 A. M.,	68·8	67·8	71·5
" " " 2 P. M.,	50·4	48·5	51·2
" " " 9 P. M.,	68·2	64·5	67·6
" " " for the month.	62·5	60·3	63·4
Clouds—Number of Clear days,* .	8	9	8·8
" " Cloudy days,	22	21	21·2
" Means of sky cov'd at 7 A. M.,	57·0 per ct.	68·7 per ct.	62·8 per ct.
" " " " 2 P. M.,	75·3	67·3	66·0
" " " " 9 P. M.,	58·0	49·0	52·4
" " " for the month,	63·4	61·6	60 3
Rain—Amount, . . .	7·294 in.	3·947 in.	5·007 in.
No. of days on which Rain fell, .	16·	11·	13·1
Prevailing Winds, . . .	N 30°8′ W. ·223	N 45°0′ E. ·047	N.64°21′W·159

* Less than one-third covered at the hours of observation.

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